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TECHNICAL REPORT M-70-6

QUANTITATIVE DESCRIPTION OF SELECTED WEST GERMAN TERRAIN FOR GROUND MOBILITY

by

H. K. Woods, J. H. Shamburger

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April 1970

Sponsored by U. S. Army Ballistic Research Laboratory
Aberdeen Proving Ground, Maryland

Conducted by U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

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Project Nos.
AJ-8-R0841-01-AJ-Q6 and 1T062-103-A046

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FOREWORD

The study reported herein was performed by the U. S. Army Engineer Waterways Experiment Station (WES) for the U. S. Army Ballistic Research Laboratories (BRL). The funds employed for this study were allocated to WES under Order No. 492-305-29, AMCMS 571 5071.11.60200, Project No. AJ-8-R0841-01-AJ-Q6. U. S. Army Materiel Command (AMC) funds under Trafficability and Mobility Project No. 1T062-103-A046 were used in the preparation and publication of this report. The study was performed during the period January-November 1968.

Field data were collected in West Germany during the months of March and April 1968 by four teams. Each team was composed of three or four men and each team was assigned the responsibility for sampling a factor family. The team captains were WES personnel and team members were personnel of the 293d Engineer Battalion (Const). Personnel who served on the teams at various times are as follows:

<u>Surface geometry factor family team</u>

Mr. H. K. Woods, Geology Branch, Soils Division, WES

SP5 B. R. Thomas (Const)

SP4 W. R. Partridge (Const)

SP4 M. Jenkins (Const)

PFC R. E. Botkin (Const)

<u>Surface composition</u>

Mr. C. A. Blackmon, Vehicle Studies Branch, Mobility and Environmental Division, WES

SP5 G. L. Carlson

SP4 B. Major

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Vegetation factor-family team

Mr. B. T. Helmuth, Terrain Analysis Branch, Mobility and Environmental Division, WES

SP4 G. D. Bumgarner

SP4 N. J. Delatte, Jr.

PFC R. W. Eaton

Hydrologic geometry

Mr. J. H. Robinson, Vehicle Studies Branch, Mobility and Environmental Division, WES

SP5 R. J. Marshall

PFC R. M. Ady

PFC D. J. McCloskey

The field work was under the supervision of Messrs. A. A. Rula, Chief, Vehicle Studies Branch, and Mr. Woods. Data were reduced and maps prepared for the terrain factors and factor families by each team captain. This report was prepared by Messrs. Woods and J. H. Shamburger, Chief, Military Projects Section, Geology Branch. All phases of the study were under the direct supervision of Mr. Rula, Dr. C. R. Kolb, Chief, Geology Branch, and Mr. Shamburger.

Special thanks are due to BRL personnel, particularly Messrs. J. W. Beach and D. E. Woomert, who participated in numerous planning meetings and furnished general guidance; CPT W. J. Hardenberg, BRL, who served as liaison officer and contributed to the success of the field program; MAJ J. C. Giambruno, Operations Directorate, U. S. Army Engineers, Europe (USAENGCOMEUR), who coordinated the field support with LTC Arnold, commanding Officer of the 293d Engineer Construction Battalion; and to the Post Commanders of the reservations visited for their excellent support and cooperation.

Directors of the WES during the conduct of this study and preparation of this report were COL John R. Oswalt, Jr., CE, and COL Levi A. Brown, CE. Technical Directors were Messrs. J. B. Tiffany and F. R. Brown.

CONTENTS

GLOSSARY

The following terms have been used in highly restricted senses throughout this report and are defined. The form in parentheses is commonly used in the text as an abbreviation. Other terms are defined as they appear in the report.

Terrain factor (factor). An attribute of the terrain that can be adequately described at any point by a single measurable value. For example, slope and stem diameter are both factors.

Terrain factor value (factor value). A specific occurrence of a terrain factor. For example, 10 deg is a factor value of the terrain factor slope.

Terrain factor family (factor family). A combination of factors that tend to exert a characteristic kind of effect on a military vehicle or activity. Four factor families are used to define the effects of terrain on the cross-country performance of vehicles: surface geometry, surface composition, vegetation, and hydrologic geometry.

Terrain factor-value class (class range). A specific range of factor values established for a specific purpose. For example, 1.5 - 4.5 deg is a factor-value class of the factor slope.

Terrain factor complex (factor complex). Any combination of two or more factors chosen for a specific purpose. They may or may not all be drawn from the same factor family.

Terrain factor map (factor map). A map delineating areas, throughout each of which the terrain is characterized by a unique factor-class value.

Terrain factor-complex map (factor-complex map). A map in which each delineated area exhibits, throughout its extent, a specific combination of factor classes, the factors having been chosen for a specific purpose. The factors may be drawn from one or more factor families. A map where the combinations of factor classes are restricted to a specific family is a terrain factor-family map (factor-family map).

The terminological scheme can be illustrated graphically:

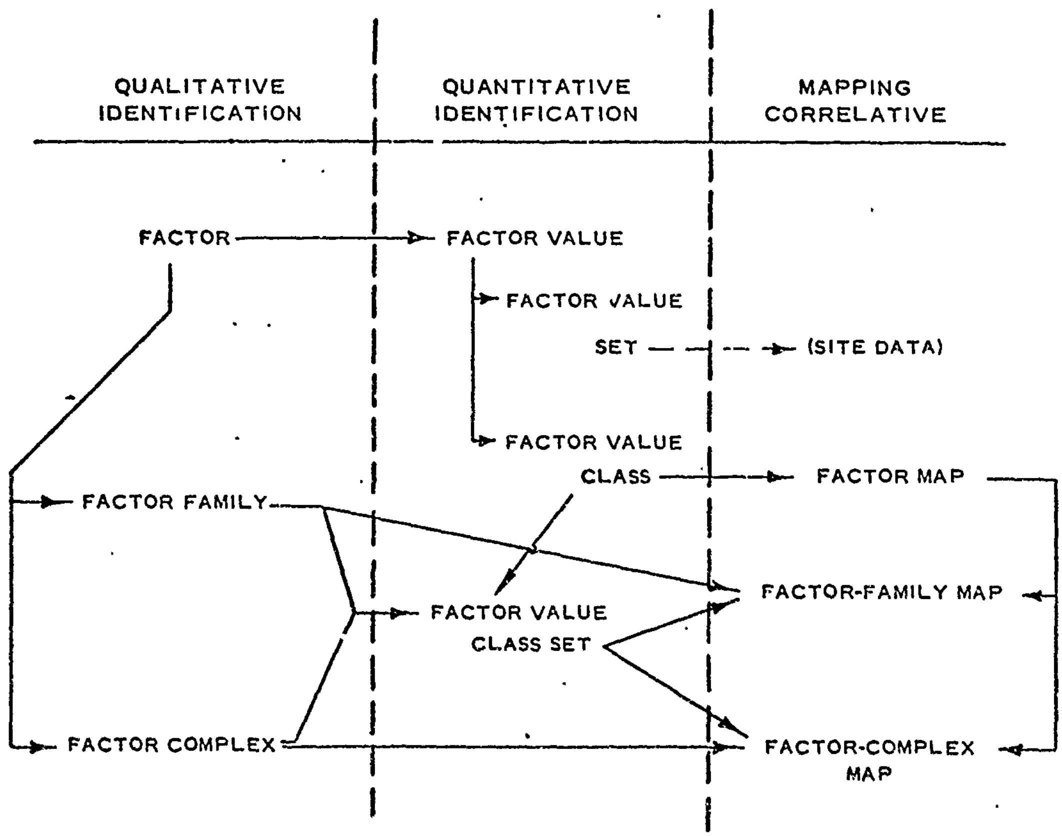


Diagram of relations among terms used in factor mapping

Ground mobility. The ability of a ground contact vehicle to move across terrain without benefit of roads or engineering assistance.

Fine-grained soil. A soil of which more than 50 percent (by weight) of the grains will pass a No. 200 U. S. Standard Sieve (smaller than 0.074 mm in diameter).

Coarse-grained soil. A soil of which more than 50 percent (by weight) of the grains will be retained on a No. 200 sieve (larger than 0.074 mm in diameter).

Organic soil. The living, dying, and dead vegetation that form a surface mat, and the mixture of partially decomposed and disintegrated organic material (commonly known as peat or muck) below the surface mat. Small quantities of mineral soil may or may not be mixed with the organic material.

Critical layer. The layer of soil regarded as most pertinent to establishing relations between soil strength and vehicle performance. In fine-grained soils and poorly drained sands with fines, it is usually the 6- to 12-in. layers; however, it may vary with the weight of the vehicle and with the soil strength profile.

Cone index (CI). An index of the shearing resistance of a medium obtained with a cone penetrometer. The value represents the resistance of the medium to penetration of a 30-deg cone of 0.5-sq in. base or projected area. The number, although usually considered dimensionless in trafficability studies, actually denotes lb of force on the handle divided by the area of the cone base in sq in.

Remolding index (RI). A ratio that expresses the proportion of original strength of a medium that will remain under a moving vehicle. The ratio is determined from cone index measurements made before and after

remolding a 6-in.-long sample that has been extracted with the remolding equipment.

Rating cone index (RCI). The product of the measured CI and the RI of the same layer.

SUMMARY

This study was performed to classify and map terrain for ground mobility purposes in accessible areas of three German military reservations (Baumholder, Bergen-Hohne, and Grafenwohr). The terrain was classified in terms of surface geometry, surface composition, vegetation, and hydrologic geometry factors that affect vehicle mobility.

Mapping of the terrain factors was accomplished through interpretation of air photos. To provide the necessary ground control data for photo interpretation processes, a field data collection program was conducted, and data were collected according to established procedures. The field data were tabulated and placed in established class ranges significant to ground mobility. Utilizing the field data, an air photo-interpretation method was applied to estimate the established terrain factor-value classes from the geometric, tonal, and textural characteristics of the air photo patterns. Terrain characteristics were extrapolated from the sample to the unsampled areas, and factor-family maps at a scale of 1:25,000 were prepared of the three study areas. The factor-family maps were then compiled into areal and linear factor-complex maps. The areal factor-complex maps display the

areal extent of discrete combinations of factor-value classes of surface geometry, surface composition, and vegetation factor families. The linear factor-complex maps display the factor values of linear features (i.e., streams, canals, road embankments, etc.) and the surface composition and vegetation associated with them.

QUANTITATIVE DESCRIPTION OF SELECTED WEST GERMAN TERRAIN FOR GROUND MOBILITY

PART I: INTRODUCTION

Background

1. During 1964 as a part of a Mobility Environmental Research Study (Project MERS) under the auspicies of the Advanced Research Project Agency (ARPA), the U. S. Army Engineer Waterways Experiment Station (WES) evaluated the state-of-the-art of terrain descriptions and terrain analysis for ground mobility purposes. It was evident from this evaluation that the descriptive system being developed at WES under the U. S. Army Materiel Command (AMC) sponsored Military Evaluation of Geographic Areas (MEGA) project was the only system sufficiently quantitative to adequately describe terrain for ground mobility. With only minor modifications the MEGA system was utilized to describe the terrain for Project MERS. This descriptive system provided terrain data input to the WES analytical model for predicting the cross-country performance of military vehicles. Development of this model was initiated under Project MERS and since 1967 work has continued under AMC project entitled "Trafficability and Mobility Research." Since the termination of Project MERS, the terrain descriptive system and the analytical model have been utilized on several other projects to predict the cross-country performance of tracked and wheeled vehicles.

2. In November 1967 representatives from the U. S. Army Ballistics Research Laboratories (BRL) visited WES to become familiar with details involved in the preparation of terrain factor-complex maps for ground mobility purposes and in the application of the WES analytical model to

predict vehicle performance. BRL was considering the possibility of using the WES model in evaluating the off-road performance of the M60A1E1 tank over German terrain as part of an overall evaluation of the MBT70 being pursued under the Department of the Army and preparing terrain factor complex maps for ground mobility of several military reservations.

3. By letter dated 4 January 1968, BRL requested WES to prepare terrain factor-complex maps for three military reservations in West Germany. These maps were to be prepared from available information and terrain data collected on site. Prior to initiation of the on-site data collection phase of the terrain study, a teletype dated 5 March 1968 was received from BRL requesting that WES evaluate the mobility of the M60A1E1 and MBT70 tanks over two traverses in the vicinity of Fulda, West Germany, for the Department of the Army comparative tank study.

4. This report deals with the terrain study in which the terrain factor-complex maps were prepared. The mobility performance evaluation is presented in a WES report entitled "Relative Evaluation of Off-Road Mobility Performance of the MBT70 and M60A1E1 Tanks in Selected West Germany Terrains (U)."[1]

Purpose

5. The purpose of this study was to prepare terrain factor complex maps of three geographically dissimilar areas in West Germany in quantitative terms as required in evaluating vehicle cross-country performance using the WES analytical model, and to present the methods and techniques used in preparing terrain factor-complex maps.

Scope

6. WES methods and techniques were used in the preparation of terrain factor-complex maps. Separate tasks included the collection and analysis of available information including maps and air photos, establishing class intervals for terrain factors for which separate maps were prepared, acquisition and analysis of ground truth data, and preparation of terrain factor complex maps by overlaying appropriate terrain factor maps.

7. Certain requirements and guidelines were imposed on this study by the sponsor. Those that were pertinent to the scope of this study and the action taken are listed below.

a. Although the terrain mapping was of general interest in evaluating any cross-country vehicle, the study included specifically the M60E1 and MBT70 tanks because of the pending comparative tank study and the time element imposed by the study. In establishing class intervals for mapping terrain factors, the effects of these factors on tanks were considered.

b. Three of five military bases located in West Germany in different physiographic regions were to be selected by WES. Sufficient hydrologic and man-made terrain features were to be superimposed on the mapped areas to make it characteristic of that particular geographic sector of West Germany. This requirement was met as stated.

c. All terrain inclosed by the reservation boundaries minus impact and built-up areas were mapped. This requirement was met as stated.

d. Maps would be prepared for both wet (spring breakup) and dry season. Only wet-season maps were prepared because soil strength data collected during the wet season revealed that soil strength would affect vehicle performance only in a few isolated areas, precluding the necessity for preparing

PART II: TERRAIN DESCRIPTIVE SYSTEM

8. The function of terrain analysis is to supply an interpretation of terrain in terms of performance values (or classes) of a military machine or activity. This study presupposes a capability for describing terrain in terms required as input to the analytical model for predicting the cross-country vehicular performance developed at WES.[2] The terrain input required by this model consists of pertinent factors described in quantitative terms. The terrain descriptive system developed under the AMC-sponsored MEGA project is designed to satisfy the input requirements of the model.[3] It should be pointed out that the MEGA system for measuring and recording terrain factors contains a substantial number of factors that are not needed for purposes of mobility analysis. Since each factor was considered as independent of all others, those not needed for this project were dropped, and only those factors that are known to produce an effect on ground mobility were retained. The result of this process was the establishment of a useful and presently adequate description for mobility purposes. This system is briefly described below.

MEGA System

9. The MEGA system for describing terrain is based on the principle that all attributes of the terrain that are significant for any specified purpose (i.e., that can be demonstrated or hypothesized to affect a military machine or activity) can be isolated and measured. A sufficient description of a specified terrain consists of the array of values obtained by measuring the significant attributes (or factors) in that terrain.

It is convenient to stratify these factor arrays in terms of the characteristic kind of effect that they impose on a specified military activity. In the present case, this is cross-country locomotion. For example, the effects produced on vehicle locomotion by the shape of the topographic surface are generally different in kind from those produced by bodies of water. Although there are many exceptions to this general rule, the suggestion remains that a division of the terrain into families of related attributes is both reasonable and convenient in the terrain description process. This grouping of terrain factors into factor families is referred to as the factor-family concept, and convenient (although not necessarily entirely accurate) names are assigned them. Thus, in table 1, the surface geometry factor family is divided into four factors, the surface composition factor family for this study consist of only one factor (soil mass strength) mapped in varying terms depending on the type of surface material the vegetation factor family is divided into eight factors (seven pertaining to structure and the eighth to visibility), and the hydrologic geometry factor family is divided into five factors. Although the individual factor families conceptually incorporate all factors relevant for all possible purposes (paragraphs 11-21),only those listed in table 1 were actually mapped for this project.

10. The apparent complexity of the descriptive system appears to be unavoidable; chiefly because all natural environments are composed of many factors, and any activity conducted therein will be simultaneously affected by many of those factors acting either individually or in concert. For example, a vehicle traversing a hill is affected by a combination of the soil consistency, the slope angle, the degree of surface

roughness, and the vegetation. On the other hand, different and varying combinations of terrain characteristics may produce the same total effect on a vehicle's performance. Thus, a combination of vegetation and soft soil may produce the same impedance to vehicle speed as does slope alone. When it is considered that terrain occurs in an almost infinite number of combinations of conditions, it is clear that any system which attempts to describe all conditions simultaneously becomes complex. The only reasonable solution appears to be to divide the total array of terrain characteristics into groups of factors that tend to act in a common manner on any specific activity. It is primarily for this reason that the MEGA system incorporates the factor-family stratification of factors, as discussed in the above paragraph. It is a convenient simplification and is not a necessary part of the terrain description process. Nevertheless, it does make it easier to define and describe the more or less naturalistic factor groups, as follows.

Factor Families

Surface geometry

11. This factor family is concerned with the configuration of the surface of the earth. Such things as slopes, ravines, embankments, ditches, and plowed fields are typical surface configurations that produce profound effects on the performance of vehicles. It must be emphasized that consideration of this factor family is governed only by actual physical shape and arrangement; it is not concerned with what caused the feature or whether it is man-made or of natural origin. In short, this factor family is

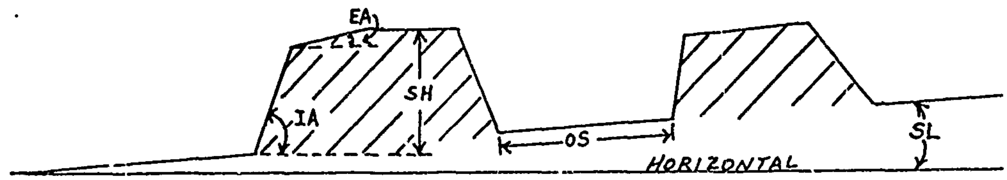
simply the geometrical configuration of a three-dimensional surface. Intensive studies have shown that the surface geometry parameters or factors that affect vehicle movement over a surface are slope, spacing of vertical obstacles, terrain approach angles, and obstacle step height. Fig. 1 portrays these factors graphically and defines the terms.

Surface composition

12. This factor family is concerned with the composition and physical properties of the materials of the surface of the earth without regard to their origin. The study reported herein is concerned chiefly with soil as an engineering material, to the exclusion of such materials as consolidated rock, snow, and ice; even though in a general sense, such materials are included in the surface composition factor family. For the purposes of analysis of terrain for various military activities, such as construction of roads and airfields, mobility of ground-contact vehicles, and construction of field fortifications, the consideration of soils is divided into three data-collection categories: soil classification, soil moisture, and engineering characteristics.

13. Soil classification encompasses the identification of basic physical characteristics, such as texture, and plasticity. The soil classification used in this study was the Unified Soil Classification System (USCS).[4]

14. Soil moisture is a basic constituent of the surface materials, but it is not encompassed in most classification systems primarily because it varies with time nearly everywhere. All other things being equal, it is the most important factor controlling soil strength. Thus, detailed



▨ Vertical obstacle

Definitions:

Vertical obstacle. A surface feature that forces a vehicle to move in a vertical plane (i.e., up and down) while surmounting it.

Slope (SL). The angular deviation of a surface from the horizontal, measured perpendicular to the topographic contours.

Terrain approach angles. The angles formed by the bounding inclines at the base and top of vertical obstacles that a vehicle must sense in surmounting the obstacle. The angles are measured with respect to the horizontal. The angle formed at the base is identified as the interior approach angle (IA). The angle formed at the top of the obstacle is identified as the exterior approach angle (EA).

Vertical obstacle spacing (OS). The horizontal distance between bases of vertical obstacles.

Step height (SH). The vertical distance from the base of a vertical obstacle to the crest of the obstacle.

Fig. 1. Surface geometry factors

information on the relation between soils and moisture content is necessary before engineering properties of the material can be predicted.[5]

15. Engineering characteristics of soils comprise a group of related factors describing specific physical properties of the soil-water system as a whole. The factor values are stated as numerical indicators derived from standard laboratory or field tests and include Atterberg limits and measures of soil strength. Soil strength for this study is measured in terms of mass strength.

16. The soil mass strength-vehicle relations for fine-grained soils, including organic mixtures, sands with fines poorly-drained, and clean sands, have been investigated in detail, and procedures for predicting the effect of soil mass strength on vehicle performance have been developed for cases in which adequate soil surface strengths are present. Similar relations for organic soils (peat) are not developed to same level of confidence. Simple and reliable instruments for measuring soil strength are the cone penetrometer and the remolding equipment. A discussion of these instruments and the procedures for their use are presented in Department of the Army Technical Bulletin.[6] For this study RCI was the unit of measurement for fine-grained soils and sands with fines poorly-drained. CI was used for coarse-grained and organic soils. The critical layer depth, 6-12 in. for fine-grained and organic soils, and 0-6 in. for coarse-grained soils was mapped.

Vegetation

17. This factor family includes two related assemblages of properties: vegetation structure and screening characteristics. Each of these properties deals with particular characteristics of vegetation as a whole.

In this context, vegetation includes all plants growing on the surface of the earth or on other plants.

18. Vegetation structure comprises the relatively gross physical attributes of plant growth. It is the geometry of the vegetation as a whole and incorporates the physical properties known or assumed to produce direct effects on military activities; the factors include stem size and spacing, height, branching characteristics, etc.

19. Screening characteristics of vegetation is an artificial property of vegetation in the sense that it is an arbitrary measure of an effect of the vegetation structure on a specific activity rather than a measure of a direct physical attribute of the plants themselves. The property measured is the effect of plant growth of varying density on visibility along selected lines of sight. Consideration of visibility, in the total s nse, involves a variety of phenomena not all related to vegetation per se. It is evidently a function of the number and size of obstructions, the amount and quality of available light, the physiological variations in the observer (e.g., color blindness or myopia), and the psychological reactions of the observer as controlled by his experience and familiarity with the specific situation.

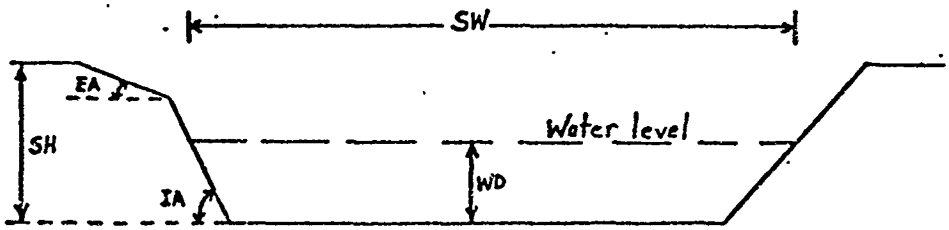
20. Vehicle tests conducted by WES have indicated that the three vegetation factors most critical to cross-country mobility are stem diameter, stem spacing, and visibility. Each of these factors was mapped in this study.

Hydrologic geometry

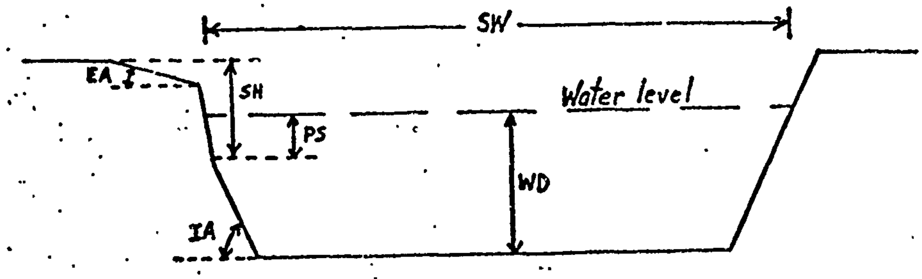
21. This factor family is concerned with the shape, size, and distribution of water bodies of all kinds. Here, temporal variance is a

matter of concern, since these shapes, sizes, and distributions of water bodies vary with time. There are also dynamic considerations such as current velocity. For example, water splash created by high current velocities may drown out an engine and immobilize a vehicle just as effectively as excessive water depth or approach angles beyond the capability of the vehicles to negotiate. All drainage features containing water regardless of depth were considered to be hydrologic geometry features. Factors used to describe the hydrologic geometry characteristics are water depth, interior and exterior approach angle, stream width, step height, and position of step base. The hydrologic geometry factors used to describe a feature are dependent upon two conditions: (a) where the water depth is less than 3 ft, and (b) where the water depth is 3 ft or greater. This subdivision was selected because most military vehicles can ford water depth less than three feet. All the factors are the same except the position of step base is not used to describe features with less than 3 ft of water, and the step height is measured differently under each water depth condition. Fig. 2 graphically portrays each condition and indicates the features used to describe each. The factors are also defined in fig. 2.

CASE I - Water depth <3 ft



CASE II - Water depth ≥3 ft



CASE I:

Water depth (WD). The greatest vertical distance between the water surface and the bottom of the channel.

Stream width (SW). The horizontal distance between the point of water-land contact on the bank to the water-land contact on the opposite bank.

Interior approach angle (IA). The acute angle the stream bank makes with the horizontal at the point the bank intersects the streambed.

Exterior approach angle (EA). The acute angle the stream bank makes with the horizontal at the point the bank intersects the ground surface adjacent to the feature.

Step height (SH). The vertical distance from the stream base to the top stream bank.

CASE II:

Water depth (WD). Same as for Case I.

Stream width (SW). Same as Case I.

Interior approach angle (IA). Same as Case I.

Exterior approach angle (EA). Same as Case I.

Step. A step is a facet of the channel bank that (a) is steeper than that portion of the bank where the interior approach angle is measured, (b) exceeds 35 deg in slope, and (c) is at least 15 cm in vertical height.

Step height (SH). Step height is the difference in elevation between the top of the bank and base of a step.

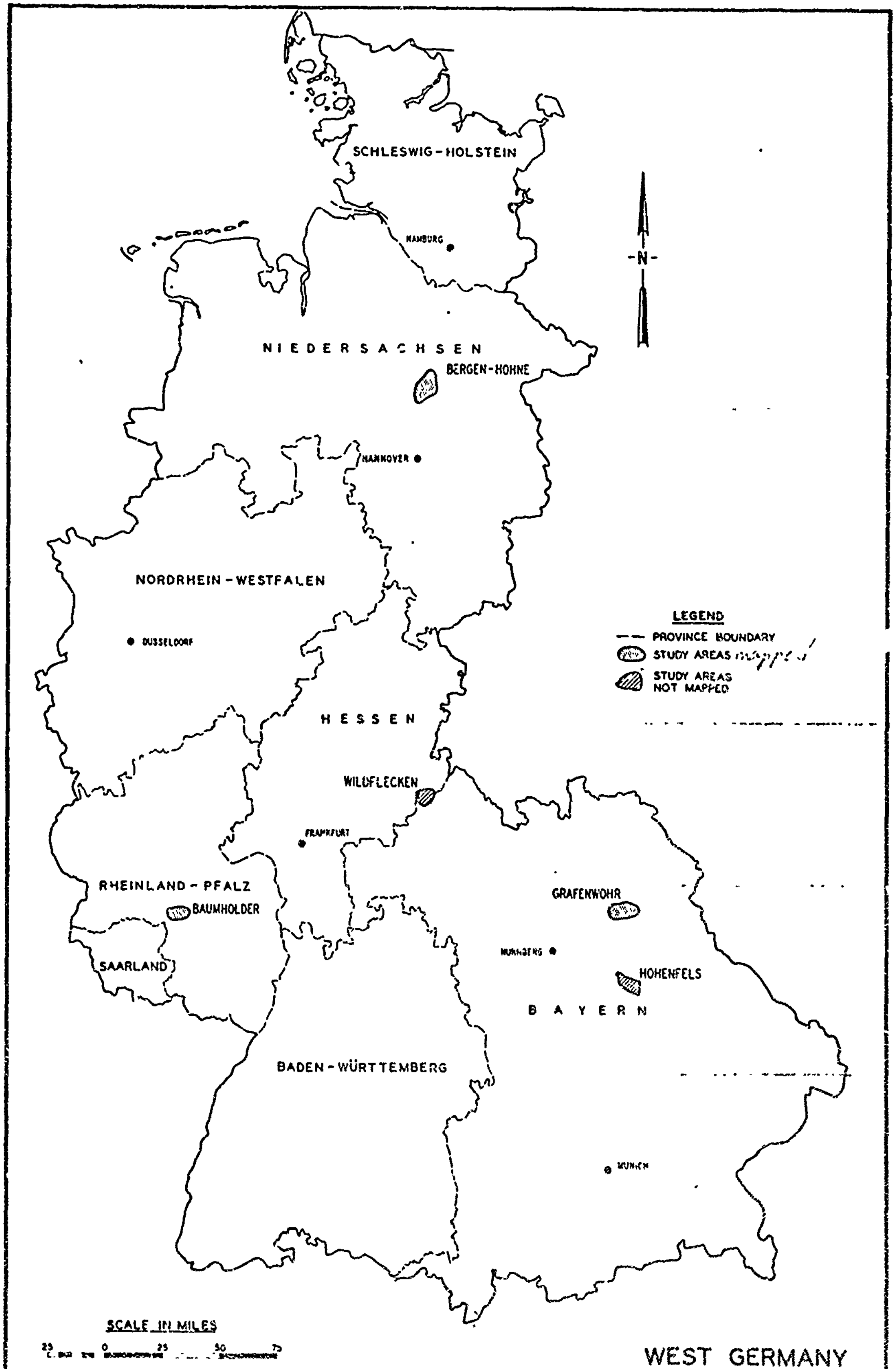
Position of step base (PS). Position of step base is the vertical distance of the base of a step above or below the surface of the water.

Fig. 2. Hydrologic geometry factors

PART III: DATA COLLECTION PROGRAM

Selection of Study Areas

22. The areas to be studied were selected on the basis of the the following considerations: (a) availability of large-scale air photographs, (b) variations of terrain conditions, and (c) accessibility of areas for field sampling with the additional possibility of conducting future mobility tests. Because a large percentage of Germany is covered with recent (1965) air photos, this time imposed practically no restriction on the selection of study areas. It is always desirable for study areas to include as much meaningful variation in terrain as possible; however, this usually requires a study to determine the terrain variations that occur within a country or region under consideration. An unrestricted choice of study areas usually involves privately-owned land where easements must be obtained. This involves time and usually money. If the selection of areas is restricted to military reservations, access problems are normally eliminated or minimized. Because of the time and fund limitation, it was felt that the objective of the study could be adequately met by restricting the selection to military reservations. Five military reservations, Baumholder, Bergen-Hohne, Grafenwohr, Wildflecken, and Hohenfels (see fig. 3), were originally chosen with the stipulation that available maps and literature covering these reservations would be studied and the three reservations containing the maximum terrain variations would be selected for detail study. From this preliminary examination Baumholder, Bergen-Hohne, and Grafenwohr were selected because the terrain at these reservations included similar types that occurred in the other two



WEST GERMANY

Literature Survey

23. A literature study was initiated to locate and review all available data, maps, and aerial photographs covering the five selected study areas. Agencies contacted prior to the field work were the Army Map Service (AMS), U. S. Geological Survey (USGS) Library, Military Geology Branch of the USGS, World Soil Management Group of the Department of Agriculture, and the Defense Intelligence Agency. A search was also made at German and American agencies in Frankfurt, Schwetzingen, Mainz, Fulda, and Hannover during the period spent in Germany. As expected, the references did not contain quantitative data in terms of the terrain factors considered for this study. Previous literature searches have resulted in locating very little, if any, data in the quantitative terms required by the WES mapping system. Results, therefore, were as expected. It should be pointed out that the majority of the references were in German and only a casual review was made. However, the few available English references proved useful in obtaining a general knowledge of the region.

24. Topographic maps at a scale of 1:25,000 were available for all the reservations. Geological maps at a scale of 1:600,000 and 1:800,000 covered Baumholder and Grafenwohr, respectively. A soil map at a scale of 1:1,000,000 and vegetation maps at scales of 1:20,000 and 1:25,000 covering all the reservations were located. The search for aerial photographs revealed that coverage flown in 1953 at scales ranging from 1:20,000 to 1:37,000 was available for large portions of the reservations and recent (1965) air photo coverage flown by the German Air Force at a scale of 1:24,000 was available for all the reservations except for about 15 percent of Grafenwohr. Both coverages were obtained through AMS. Unfortunately,

the recent coverage was not received until the field work was completed. However, aerial mosaics compiled from the 1965 coverage were available prior to the field work and were very useful.

Site Selection and Field Sampling

25. The field data collection program began on March 13, 1968 and terminated on April 24, 1968. During the course of the field investigation, the following number of sites were sampled:

Military Reservation	Number of Sample Sites SG	SC	VEG	HG	TOTAL
Baumholder	29	51	21	43	144
Bergen-Hohne	29	50	26	36	141
Grafenwohr	41	50	22	33	146
Total	99	151	69	112	431

The location of each site in the reservation is shown in figs. A1, A2, and A3 in the Appendix.

27. Sample sites were selected by studying air photos, photomosaics, and topographic maps, and making ground reconnaissance. The mosaics were examined to identify variations in tone and texture indicative of different terrain conditions. After the sites had been selected, their locations were spotted on the topographic maps. A limited ground reconnaissance was made to verify the selected sites, so that any significant terrain variations that had not been previously recognized could be detected.

28. The sites were then assigned to the teams; the surface geometry sampling team was given those for which the principal reason for selection was surface configuration; the vegetation team was given those selected as illustrative of distinctive vegetation patterns; etc. As the sampling

progressed, additional sites were selected by the team captains at locations where the variations in characteristics of a factor had not previously been sampled. The methods employed to collect data for each of the terrain factors are discussed in the following paragraphs.

Surface geometry

29. Field data collected for surface geometry factors were almost exclusively in the form of profiles. Sufficient profiles were taken so that any feature could be reconstructed and the desired information for each factor obtained for mapping. These profiles were run with a site marker transit, a steel tape, and a Philadelphia rod. The length of profile depended upon the feature(s) being sampled. The data were recorded as shown in fig. 4. Where isolated features such as escarpments and road embankments occurred, the slopes at the top and bottom of the face were measured with a Brunton compass. The vertical distance or height of the face was measured with a Philadelphia rod except where the height exceeded 12 ft, and in these cases it was estimated.

Surface composition

30. Surface composition data collected in the field included (a) CI readings, (b) RI, (c) soil profiles, (d) bulk samples, and (e) supplementary site data. At each site, 10 CI penetrations were made in an area approximately 10 by 20 ft in size. For each penetration, the CI was measured at the surface, and then at 3-in.-vertical increments down to a depth of 18 in. When an unrealistic (very high) reading occurred due to rock fragments or rootlets, the penetration was started a few inches to the right or left of the original point. When the soil was very firm, CI values were taken in 1-in.-vertical increments to a depth of 3 in. Where

SURFACE GEOMETRY PROFILE DATA

PAGE 1 OF 1

Bergen Hohne

COUNTRY: W Germany (1-3) SITE NO.: 23 (4-7) SAMPLE NO.: 1A (8-9) FACTOR FAMILY: 3 (10) DATA FORM REFERENCE: 10 (11-12) DATA GROUP: 03 (13-14) DATE: 9 April 1960 (CURRENT)

ITEM NO. (15-17)	PROF. AZIMUTH (18-20)	PROFILE NO. (21)	PROF. OFF-SET (22-24)	HEIGHT OF INSTRUMENT FEET (25-26)	(27-28)	STATION NO. FEET (29-32)	(33-34)	VERTICAL OFFSET FEET (35-36)	(37-38)	STATION NO. FEET (39-42)	(43-44)	VERTICAL OFFSET FEET (45-46)	(47-48)	STATION NO. FEET (49-52)	(53-54)	VERTICAL OFFSET FEET (55-56)	(57-58)	STATION NO. FEET (59-62)	(63-64)	VERTICAL OFFSET FEET (65-66)	(67-68)
001	355	1	0 00	04	90	0002	06	04	80	0002	08	03	60	0005	06	03	63	0006	00	05	43
2						06		6	0	08	0	6	00	10	0	6	03	10	6	5	52
3						10	6	5	50	11	3	5	24	1	08	4	04	4		3	98
4						14	7	4	46	15	6	4	58	15	10	5	54	16	6	5	40
5						20	0	5	42	23	6	5	44	23	08	4	86	24	4	4	92
6						4	7		16	5	8		28	5	10	4	63	6	4	4	66
7						26	6	5	07	27	4	5	11	28	0	4	73	29	0	4	14
8						30	0	4	24	31	0	4	34	32	0	5	26	34		5	22
09						4	2	4	9	4	9	5	07	5	6	5	13	36		5	58
10						37	0	5	44	37	1	3	94	39	0	3	62	40		3	83
11						41	6	4	10	41	7	5	66	42	6	6	02	5		6	12
12						46		5	42	47	4		40	47	7	3	78	0049	00	03	56
013	355	1	0 00	04	90	0050	06	04	04	0050	07	05	12	0053	00	05	28				

CREW:

Woods

Botkin

Jenkins

Portridge

Harvested Peat Area

Grid Coord: 594480

WES FORM NO. 1663
DECEMBER 66

Fig. 4. Surface geometry data form

soil conditions permitted sampling, RI was measured for the 0- to 6- and 6- to 12-in. layers. These above data were recorded on forms as shown in fig. 5. A pit was dug at each site to a depth of 18 in. (where possible), and a soil profile describing each horizon was recorded. Field techniques were used to describe the soil type. Bulk samples were taken at representative sites for laboratory determinations of soil type, organic content, and moisture content. Supplementary site data obtained at each site included general statements as to the topographic position, slope, land use, vegetation cover, and depth to the water table. These data were recorded on a form as shown in fig. 6.

Vegetation

31. Structure. The vegetation structure was sampled using the structural cell technique. In brief, a structural cell may be defined as "minimum area which includes a statistically significant sample of all the important variations in terms of selected parameters, present in a given plant assemblage."[7]

32. In theory, there exists a separate structural cell for every measurable feature of a given plant assemblage. Thus, a structural cell may be generated on any one or any combination of parameters. For example, the major interest in this study was the distribution of tree stems of specific diameters. Therefore, specific stem diameter classes (>1, >2.5, >4, >5.5, >7, >8.5, and >10 in. in diameter) were chosen as a basis for the structural cell.

33. The parameter chosen to generate the structural cell is called the cell determinate factor or the determinate factor. Thus, in this report the determinate factor was a specified range of stem diameters.

WES FORM NO. 1424
JULY ' 4

TEST NO. BHS-33 LOCATION Bergen, Germany DATE 6 April 1968

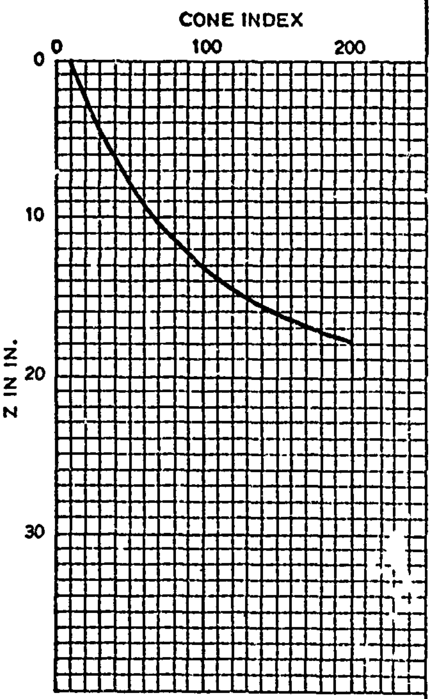
Grid coord 533494

Site is near drainageway that feeds lake

CONE SIZE 0.5 in.^{2} SHAFT SIZE Standard

CONE INDEX

SFC	3	6	9	12	15	18	24	30					
10	30	40	40	140	180	300	+						
5	30	30	35	45	140	300	+						
5	20	80	50	200	300	+							
5	20	30	40	50	100	300	+						
5	20	30	40	80	140	300	+						
10	20	40	50	60	100	180	300	+					
10	20	30	40	50	60	80	100	100					
20	40	50	100	100	90	120	80	100					
10	30	30	40	40	40	50	80	80					
10	20	40	100	90	80	80	70	80					
9	25	40	54	86	123	201	+ –	–					
CI													
RI													
RCI													



REMOLDING INDEX

DEPTH	0-6"		0-6"				6-12"		6-12"											
-	0	25B	0	25B	0		0	25B	0	25B	0		0		0		0		0	
SFC.	20	10	10	10			20	10	30	20										
1	30	15	20	10			30	15	50	30										
2	30	15	30	15			40	20	60	40										
3	30	15	30	15			35	20	60	20										
4	30	15	30	15			50	20	60	20										
TOTAL	140	70	120	65			175	85	260	130										
R. I.	0.50		0.54				0.48		0.50											

MOISTURE CONTENT & DENSITY

DEPTH	0-6"		6-12"							
CAN. NO.	91L		236 X							
WET & CAN	206.8		227.8							
DRY & CAN	120.0		120.5							
WATER	86.8		107.3							
CAN	100.0		102.0							
DRY SOIL	20.0		18.5							
% MOISTURE	434.0		580.0							
DRY DENSITY										

Supplementary Site Data

Site No. BHS 33 Location: Bergen Germany 533494

Sampling Team: Blackmon & Woods Page ____ of ____

Land Use (Select as many as required to describe condition: circle appropriate terms.)

1. Not obviously used by man or domestic animals. Undisturbed.
2. Obviously used by man or domestic animals.
   a. Cropland currently in use (excluding hayfields, orchards, vineyards, tree plantations). Type ________
   b. Cropland currently lying fallow (excluding hayfields, orchards, vineyards, tree plantations). Type ________
   c. Area grazed by domestic animals
   d. Hayfields (not currently being grazed)
   e. Orchards, vineyards, tree plantations. Type ________
   f. Lawns, recreation areas
   g. Logged, cut for fuel, newly cleared for slash-and-burn agriculture

Depth of water over soil surface (if any): Water ponded on surface

Depth below surface of free water (if any): 24"

Depth to bedrock (if any): >36"

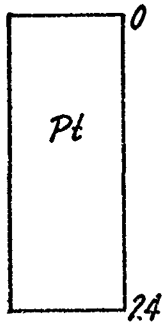
Vegetation (select one, if possible. If a choice between two is difficult, indicate both.)

1.	Forest	5.	Tall scrub woodland	9.	Tall-grass prairie
2.	Woodland	6.	Tall scrub savanna	10.	Short-grass prairie
3.	Savanna	7.	Low scrub	11.	Barren
4.	Tall scrub forest	8.	Low scrub savanna		

Maximum topographic slope: 2% N 30°W

Topographic position: Bottomland flat (Marsh)

Profile Sketch



Moist, matted vegetal matter with small amount of sand
Black, 6YR 2/0

Some clay found at creek but not at site

Hardwoods 2"-6" diam.
8' spacing
Random surface irregular
6" relief
Visibility 30' due to scrub

WES Form No. 1419
June 1964

In general, each vegetation sample that is described should be large enough to encompass most of the structural variations existing in the stand as a whole. It has been determined that most vegetation structures are adequately described when the sample is a circular area incorporating 20 members of the determinate population.

34. The sampling procedure used for vegetation structure can be briefly described as follows. A cell center was selected at any point within a vegetation assemblage and a site marker transit set up over this center point. From the center point the distance to the closest stem (tree) was measured. This stem was identified as stem number 1, and its position and all data pertinent to this stem were recorded under the appropriate column on a vegetative structural data form (see fig. 7). This procedure was repeated, moving always in a circular direction around the center point to ensure proper sampling of each stem. The next closest stem was measured and recorded in the same manner as was stem number 1. This process was continued until approximately 20 of the most frequently occurring stems of the largest diameter had been measured and recorded. To avoid confusion, each stem was flaged as the data were recorded. The cell diameter is twice the distance from the center point to the furthest cell determinate stem. The method used to determine the average spacing of stems is discussed in the data reduction section.

34a. Visibility. Visibility was sampled at each vegetation structure site before the structural data were taken so the the vegetation would not be altered by any trampling that might occur during the structural sampling. The sampling procedure at each site was as follows. The site marker transit was set up over the center point of the cell and the line of

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VEGETATION STRUCTURE

Baumholder

COUNTRY: W. Germany   SITE NO.: 1   SAMPLE NO.: 1   Grid Coord: 828026   PAGE 1 OF 1   DATE: 13 Mar 1968

STEM DATA

Country	Site Number	Sample Number	Factor Family	Data Form Reference	Data Group Reference	Components in Site	Component Number	Line Number	Lines per Component	Cell Number	Determinant Data Group	Determinant Field	Height of Instrument (feet)	Height of Component (feet)	Attachment	Distance from Cell Center (feet)	Azimuth	Elevation of Base (feet)	Number of Bases	Base Diameter	Middle Stem Diameter (feet)	Upper Stem Diameter	Height of First Stem Furcation	Number of Buttresses	Component Axis to Most Distant Base	Attitude	Sinuosity	Hardness	Length of Stem Spines	Irritants	Nomenclature	Comment
0.5.3	0.0.0.1	0.1	4	1.0	0.4	0.5.4	0.0.1	0.1	0.1	1			5.0.0	0.0.0	1	0.0.0	1.7.8	0.4.8.1			0.7.7											
			4	1.0	0.4		.2							0		.2.5	1.7.5	.5.0.3			.8.0											
			4	1.0	0.4		.3							5		.6.5	2.1.8	.4.9.8			.8.1											
			4	1.0	0.4		.4							.4		1.9.0	.5.9	.5.0.7			.9.0											
			4	1.0	0.4		.5							.4.0		.1.5	.6.1	.4.8.6			.6.3											
0.5.3	0.0.0.1	0.1	4	1.0	0.4	0.5.4	0.0.6	0.1	0.1	1			5.0.0	0.0.3.8	1	0.2.0.0	2.7.3	0.4.6.8			0.5.5											

BRANCH AND FOLIAGE DATA

Country	Site Number	Sample Number	Factor Family	Data Form Reference	Data Group Reference	Components in Site	Component Number	Line Number	Lines per Component	Continuation Number	Branching Height (feet)	Branch Width	Branch Thickness	Number of Edges	Branch Angle	Branch Length	Branch Tip Height	Azimuth to Branch Tip	Furcation Type	Length of Branch Spines	Location	Irritants	Leaf Length	Leaf Width	Leaf Thickness	Leaf Condition	Length of Leaf Spines	Location	Sharp Edges	Irritants	Comment
0.5.3	0.0.0.1	0.1	4	1.0	0.5	0.5.4	0.0.1	0.1	0.1	0.1	0.0.2.5																				
			4	1.0	0.5		.2				3.0																				
			4	1.0	0.5		.3				.1																				
			4	1.0	0.5		.4				0																				
			4	1.0	0.5		.5				3 0																				
0.5.3	0.0.0.1	0.1	4	1.0	0.5	0.5.4	0.0.6	0.1	0.1	0.1	0.0.2.8																				

CROWN DATA

Country	Site Number	Sample Number	Factor Family	Data Form Reference	Data Group Reference	Components in Site	Component Number	Line Number	Lines per Component	Continuation Number	Distance to Crown Center	Azimuth to Crown Center	Azimuth of Primary Plane	Vertical Dimension of Primary Grid (feet)	Horizontal Dimension of Primary Grid (feet)	Intercepts on Line A	Intercepts on Line B	Intercepts on Line C	Intercepts on Line D	Intercepts on Line E	Vertical Dimension of Secondary Grid (feet)	Horizontal Dimension of Secondary Grid (feet)	Intercepts on Line F	Intercepts on Line G	Intercepts on Line H	Intercepts on Line I	Intercepts on Line J	Comment
0.5.3	0.0.0.1	0.1	4	1.0	0.6	0.5.4	0.0.1	0.1	0.1	0.1				0.0.1.5	0.0.1.0	2.4	2.5	1.6	2.6	2.4	0.0.1.5	0.0.0.8	2.4	2.5	1.6	2.5	2.4	
			4	1.0	0.6		.2							.4	.0		1.		1.	2 5	.4	.1.0		1.5		1 6	2.5	
			4	1.0	0.6		.3							.1	.2		2.			1.6	.4	.2		2.5			1.6	
			4	1.0	0.6		.4							.4	.4		1.5				.0	.4		2.5				
			4	1.0	0.6		.5							.0	.1.0		2.4					.0		2.4				
0.5.3	0.0.0.1	0.1	4	1.0	0.6	0.5.4	0.0.6	0.1	0.1	0.1				0.0.1.0	0.0.0.8	2.4	1.6	1.6	1.6	1.6	0.0.1.0	0.0.1.0	2.4	1.6	1.6	1.6	1.6	

NEW JAN 1968 1666

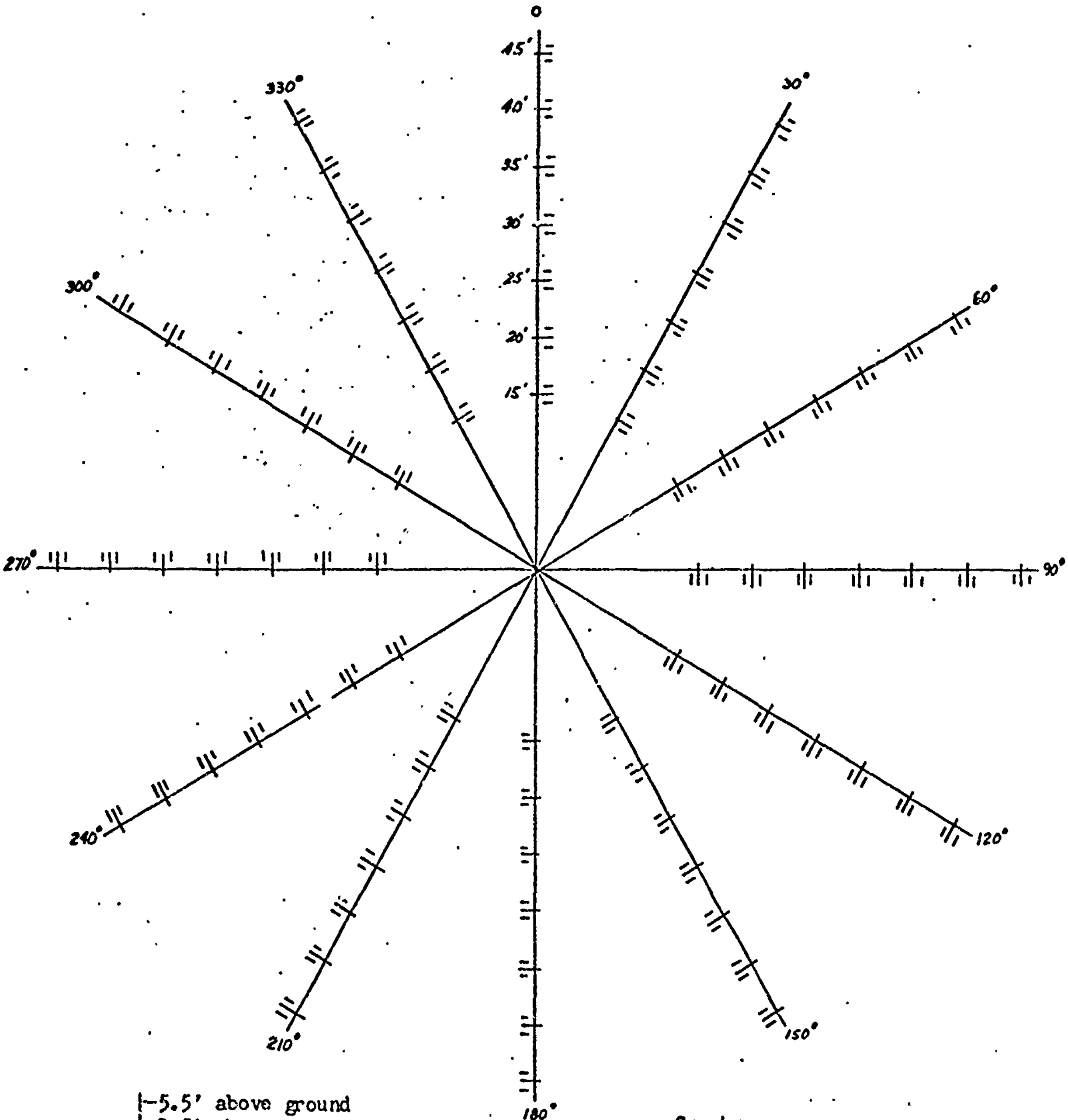
Fig. 7 Vegetation data form

sight oriented toward magnetic north. Magnetic north and other directions that were taken were determined with a Brunton compass. The rodman, carrying 10 targets of various shapes (circles, rectangle, star, triangle, etc.) with a maximum dimension of 1 ft, proceeded to a distance of 15 ft from the cell center and stopped just outside the line of sight. At this point each target was held at three heights above the ground (1.5 ft, 2.5 ft, and 5.5 ft) and the ability or inability to recognize the shape of all targets was recorded on a form (fig. 7a). After these data were taken, the rodman continued outward along this azimuth, stopped every 5 ft, and repeated the procedure of holding the targets at each height until a distance of 45 ft from the center was reached. The same procedure was repeated along azimuths every 30 deg around the center point and was concluded at an azimuth of 330 deg.

Hydrologic geometry

35. The field sampling of hydrologic geometry features was similar to that of surface geometry features in that it consisted of taking profiles perpendicular to the feature. A starting point was selected some 50 to 75 ft from the water's edge of a bank or a distance that would encompass the feature, and a base line perpendicular to the feature was established. The azimuth of the base line was determined with a Brunton compass. A steel tape was placed at the original point and extended along the base line to a terminal point 50 to 75 feet from the water's edge on the opposite bank. Horizontal measurements, such as positions of vertical offsets, were read directly from the tape. Stadia were read in place of the tape to determine the horizontal distances along the base line of hydrologic features that exceeded 3 ft. Vertical offsets and depth of

VISIBILITY



|-5.5' above ground
|-2.5' above ground
|-1.5' above ground

× Denotes targets recognizable

∘ Denotes target not recognizable

Country: ____________

Site No.: ____

Sample: ____

Grid Coord: ________

Date: ______

Fig 7a. Visibility data form

water along the profile were taken with the transit and a Philadelphia rod. Where the water was too deep for wading, the rodman used a rubber boat. All of these data were recorded on a form as shown in fig. 8.

36. CI readings were taken along both banks of the feature and in the streambed. These data were recorded on the same form used to record surface composition data (fig. 5). The number and spacing of the CI readings were left to the discretion of the team leader. Normally, five readings were taken along each bank and three were taken in the streambed, except where rock fragments prevent accurate readings.

37. When practical, current velocities were measured at several points along the cross section, with the points chosen to give a reasonably reliable current velocity profile across the channel. The velocity was measured by placing a wood chip in the water and measuring the time required for it to travel a specified distance.

Supplementary data collection

38. In addition to quantitative measurements of terrain conditions, ground photographs are extremely helpful in documenting terrain features. During the field work, each team selected views that would be of benefit in describing terrain features. Selected photographs taken within each reservation are included in this report (photographs 1-22). The locations of the photographs are in terms of military grid coordinates.

Data Reduction

39. Field data were reduced to a form suitable for use in preparing the individual factor maps. Existing forms were used or special forms

HYDROLOGIC GEOMETRY PROFILE DATA

PAGE 1 OF 1

COUNTRY: W. Germany (Grafenwöhr) (1-3) SITE NO.: 15 (4-7) SAMPLE NO.: 1 (8-9) FACTOR FAMILY: 2 (10) DATA FORM REFERENCE: 10 (11-12) DATA GROUP: 03 (13-14) DATE: April 18, 1968 (CURRENT)

ITEM NO	PROF AZIMUTH	PROFILE NO	PROF OFFSET	HEIGHT OF INSTRUMENT	STATION NO. FEET	VERTICAL OFFSET FEET	STATION NO FEET	VERTICAL OFFSET FEET	STATION NO FEET	VERTICAL OFFSET FEET	STATION NO. FEET	VERTICAL OFFSET FEET	VERTICAL OFFSET AT WATER LEVEL FEET
15 16 17	18 19 20	21	22 23 24	25 26 27 28	29 30 31 32 33 34	35 36 37 38	39 40 41 42 43 44	45 46 47 48	49 50 51 52 53 54	55 56 57 58	59 60 61 62 63 64	65 66 67 68	69 70 71 72
0.0.1	2.1.0	1	0 0.0	0.4 7.5	0.0.0.0 0.0	4 7.0	1.0 0.0	4 7.5	2.0 0.0	5 3.2	2.1 0.0	4 7.2	
.2					2.5 .0	0.2	2.7 .0	3 6.2	2.9	3 5.4	3.2 0.	4 2.8	
.3					3.4 .4	4 9.0	3.4 .9	3 3.6	3.5	6 2.0	3.5 1.	6 4.4	6 4.4
.4					3.8 .0	6 7.4	4.0 .0	6 8.4	4.2	8.5	4.4 0.	8.2	
.5					4.6	9.1	4.8	9.8	5.0	9.5	5.2 0.0	6 9.5	
.6					5.4 .0	9.0	5.6 .0	6 6.6	5.7	6 4.4			6 4.4
.7					5.7 .8	6 3.9	5.7 .8	5 0.0	5.9	4 2.0	6.1 0.0	3 6.1	
.8					6.2 .0	3 6.2	6.3 .0	3 8.2	6.4	3 9.9	6.5	4 2.0	
.9		1			0.7.0	4 3.5	7.3 0.0	4 3.6	8.3 0.0	3 6.5	9.0 0.0	3 2.9	
0.0.10	2.1.0		0 0.0	0.4 7.5	0.1.0.0 0.0	2 9.2							

CREW:

Robinson

Marshall

McCloskey

ADA

Grid Coord: 977017

stream velocity 1 ft/sec

WES FORM NO. 1658
DECEMBER 66

Fig. 8. Hydrologic geometry data form

were made to record the reduced data, making them readily accessible during the mapping phase. Field data summaries are presented in Appendix A.

Surface geometry

40. Surface geometry profiles were plotted from the field data. The profiles were plotted using the same vertical and horizontal scale so that true values could be taken directly from the profiles. Values for spacing of vertical obstacles, interior and exterior approach angles, and step height were obtained from the profiles at each sample site and recorded on data summary sheets. The profiles were generally not long enough to obtain the meaningful slope values; therefore, slope was mapped from the topographic map.

Surface composition

41. Soil data collected at each site were reduced to obtain an average value for the CI and RI, where required RCI was computed and laboratory tests were run on the soil samples to obtain a laboratory classification to check the field classification. Only the CI values were used for coarse-grained and organic soils, and the CI and RI were used to obtain RCI values for fine-grained soils. An average CI value for each depth (0, 3, 6, 9, 12, 15, and 18 in.) was obtained from the 10 measurements made at each site. These average values were used to calculate average CI's for the 0- to 6-in., 6- to 12-in., and 12- to 18-in. layers. At sites composed of fine-grained soils, the RI's and the CI's were used to compute the RCI for each probe in the 6- to 12-in. layer. All probes were then averaged to obtain the RCI for each site. Laboratory analyses of the bulk samples from representative sites were

performed. These tests determined the moisture content, density, percent saturation, specific gravity, liquid limit, plastic limit, and organic content.

Vegetation structure

42. The vegetation data were reduced and average spacing values for each of the stem diameter mapping categories (>1.0, >2.5, >4.0, >5.5, >7.0, >8.5, and >10.0 in.) were computed using the following equation:

$$S = \frac{D}{\sqrt{N}}$$

Where

S = stem spacing, ft

D = cell diameter, ft

N = number of stems

The cell diameter and number of stems for each of the above-mentioned mapping categories were obtained directly from the field data sheets recorded in the field. For example, at each vegetation site, the cell diameter D was determined by a circle that included the stem farthest from the center of the cell (this value is a constant for each site). Then all stems >1 in. in diameter were counted within the circle to obtain a value for N . The two values were substituted in the above equation and the spacing of stem >1 in. was computed.

43. The N values for the remaining stem diameter mapping class (>2.5, >4.0, etc.) at each site were obtained by simply counting the stems within the cell that were included in each of the classes and substituting the appropriate values in the equation to obtain the stem spacing for that

map class. The calculated stem spacing values for each site were recorded on summary sheets.

Visibility

44. The visibility data were extracted directly from the field data and placed in the appropriate class range. The reason for recording only one visibility value, even though visibility was collected at three heights, was that the understory was so uniform that when one target was visible, the other two targets were also visible.

Hydrologic geometry

45. The procedure for reducing the hydrologic geometry field data was similar to that used for surface geometry. Profiles were constructed from the field data and plotted with the same horizontal and vertical scale. The water level at both banks was plotted on the profile from which the stream width and water depth were measured. The interior and exterior approach angles, step height, and position of step base (if present) were measured directly from the profiles. As pointed out in paragraph 21, the method of measuring some of the factors was dependent upon whether the water depth was less or greater than 3 ft. After the water depth category was determined at a site, the appropriate measurements were made (see fig. 2). Stream velocity was a simple computation of the time required for a wood chip to float an established distance. Where more than one velocity was taken at a site, the velocity values were averaged. Average cone index values for the 6- to 12-in. layer were computed for each bank and the streambed using the procedure discussed in paragraph 41.

Factor Classification

46. The terrain factors (table 1) that were measured had been isolated in previous WES studies because they were essential to the vehicle performance prediction model. Further, the factor complex maps, an end product of the terrain description process, would graphically portray the data from which the terrain factor input to the performance prediction model is obtained. However, in order to show factor values as areal or linear phenomena rather than as a number of isolated points, it is necessary to erect classes of factor values. Each such factor-value class is a map unit.

47. This process of fitting classes to vehicle characteristics is relatively simple; however, it is complicated by the fact that the classes also have to be recognizable, or at least interpretable, from air photos because the only practical method of extrapolating data to unsampled areas is by means of photo interpretation. Little is accomplished by insisting on a class interval if that class can not be mapped. Conversely, if the class interval is too large the total effect produced may occur in one class. As a result the desires of the mobility predictors and ability of the photo interpreters were compared, and a compromise was made in finalizing the class interval. The agreed upon class ranges are shown in table 1.

PART IV: INTERPRETATION AND MAPPING TECHNIQUES

48. The data collected by the field teams described only the terrain characteristics at the exact places where the data were taken. In order to map the distribution of factors and factor values for every point in the three reservations, a method had to be applied for extrapolating the scattered point data represented by the samples to describe the entire area. Since the only other data that covered the entire reservations were maps and air photos, this meant that, for all practical purposes, the problem was reduced to one of applying map and air-photo interpretation techniques (principally the latter) to map the specific areas within reservations in terms of terrain factor classes.

49. The available air photos for this project were at a scale of 1:24,000. The date of the photography was 1965 except for about 15 percent of the Grafenwohr Reservation, which was flown in 1958. The quality of 1965 photography was excellent and the older photography was considered good.

Air-Photo Interpretation Techniques

50. Two approaches can be followed for ascertaining the characteristics of features in air photos. These are (a) direct measurement and (b) inference or interpretation based on the pattern the features exhibit in the photograph. Naturally, where ground measurements were available, these data were used to identify the feature as well as to assist in extrapolating characteristics in similar patterns in unsampled areas.

51. The ability to make direct measurements from air photos is dependent upon scale and quality of the photos, the physical characteristics of features to be measured, and the increment of measurement. The factor characteristics in the increments required by this study coupled with the photo scale (1:24,000) made practically all measurements from air photos unreliable or impossible. Because of the above, it was necessary to assign factor classes through inference or interpretation of the air-photo patterns exhibited by the factors. Actual field measurements plus observations made during the field work in areas other than the sample sites were used to the maximum extent in assigning factor classes to the air-photo patterns. Photo-interpretation criteria used during this study are briefly discussed in the following paragraphs.

Surface geometry

52. Photo interpretation keys used to map the class ranges of the surface geometry factors were difficult to establish. However, an association between the topographic position and patterns exhibited by soil type was a general indicator of surface expressions. Ground truth data and extensive ground reconnaissance were used to assign values to photo patterns and to extrapolate into unsampled areas. Large surface geometry features could be identified on the air photos through stereoscopic examination and the appropriate values assigned from the field data.

Surface composition

53. Identification of soils types on air photos was made through the association of topographic position and tone and texture with field data. The peat and organic soils (PT, OL, and OH) are easily recognized on air photos because of their relatively low topographic position and

fine-textured pattern with various shades of gray. The light to dark gray tones are indicators of the moisture content. Various tones of gray with a smooth to slightly granular texture are indicative of the silts (ML) and silty sands (SM). These soil types occurred between the topographic highs down to the transitional zone bordering the drainageways. A mixture of clays (CH, CL), silts (ML), and poorly graded sands (SP) characterized by a linear band are associated with the drainageways. This band was usually medium to dark gray with a medium texture.

Vegetation

54. Air-photo patterns and associated field measurements were relied upon almost completely in determining vegetation characteristics because stem diameter and spacing could not be measured directly from the available photographs. Forested areas were almost entirely composed of stands of pine trees with a few scattered hardwoods. Grasses and/or scrub occupied the remainder of the vegetated areas. Air-photo patterns with a smooth texture and dark gray tone are indicative of planted pines with stems up to 6 in. in diameters, which are usually spaced less than 6 ft apart. A slightly granular pattern with shades of medium to dark gray indicates maximum stem diameter of 10 in. and stem spacing up to 15 to 30 ft. Stands of hardwood trees are distinguished from the pine stands on a photograph by their lighter gray tone, mottled texture, and larger nonuniform crowns.

Hydrologic geometry

55. The streams and drainageways were identified by their narrow linear patterns on air photographs. Lakes and ponds appear as textureless patterns with medium to dark gray tones. In classifying hydrologic features, ground truth data at specific sites were used to extrapolate to unsampled stream segments.

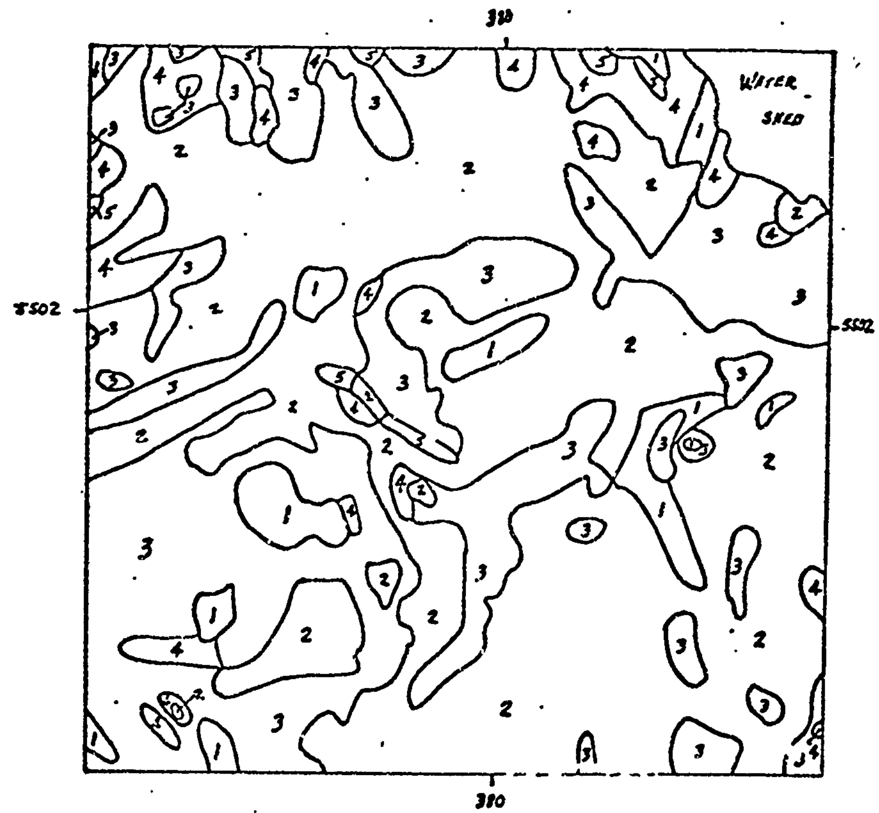
Factor-Family Mapping

56. Before the air photos were studied, the data collection site locations were plotted on the photomosaics. Drafting, reproduction, and symbol recognition considerations dictated that the minimum width of any delineated area would be approximately 1/10 in.; thus, the smallest mappable unit would be a circle 1/10 in. in diameter on the base maps (scale 1:25,000). Each site was annotated on the photomosaic with the appropriate class designations for utilization during the photo-interpretation phases of the study. This sequence was followed individually for each factor family. The procedure used to compile the factor maps is discussed in the following paragraphs.

Surface geometry

57. Slope. Slope was mapped principally from topographic maps, but air photos were used in certain special cases. To facilitate the mapping, a transparent template was constructed having a series of circles with diameters equal to the horizontal distance between contours at each break in the slope classes. The template was manipulated over the topographic sheets, isolating outlining, and identifying areas characterized by the various slope classes. Fig. 9 is a slope-factor map of a portion of the Baumholder study area. It should be noted that the slope values in the factor maps are mainly descriptors of topographic slopes, without annotation as to direction of slope.

58. Spacing of vertical obstacles. Where recognizable, the spacing of vertical obstacles was determined from air photos by using a transparent template with a scale having graduations representing the limits of each



LEGEND

Map Unit	Slope deg
1	0 - 1.5
2	>1.5 - 4.5
3	>4.5 - 10
4	>10 - 17
5	>17 - 22
*6	> 22 - 27
*7	> 27 - 31
*8	> 31

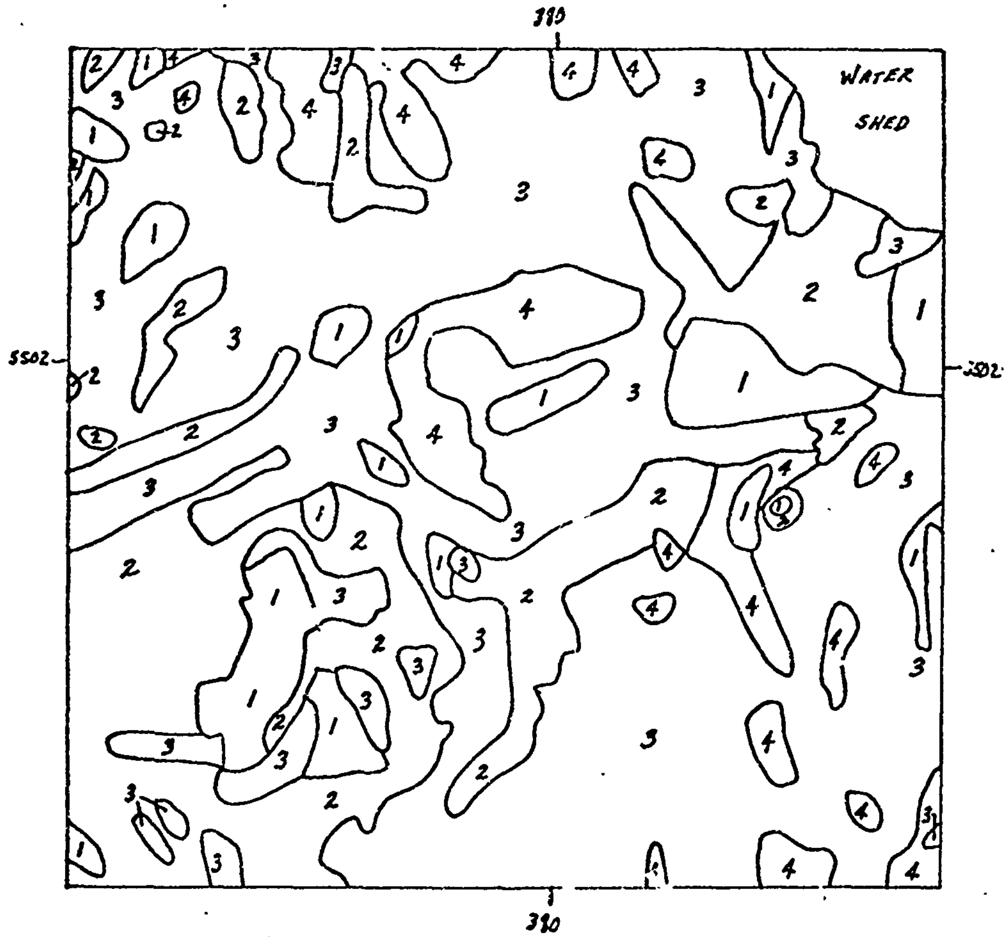
*Units not on this map

Fig. 9. Slope factor map - Baumholder

mapping class. Spacing of obstacles that could not be measured on the air photos was correlated with patterns where ground data were available. Areas were delineated, and mapping classes were assigned on the photomosaics and then transferred to the mapping base sheets. Fig. 10 is a spacing-of-vertical-obstacles factor map of a portion of the Baumholder study area.

59. Terrain approach angles and step heights. The photomosaics with the site locations and corresponding class values were the point of departure in the identification and mapping of the terrain approach-angle and obstacle step-height factors. All distinctive air-photo patterns were identified on the photomosaics. After these patterns had been delineated and described, they were then identified in terms of factor class values. Where sample sites occurred within a pattern, the class ranges for terrain approach angle and step height were assigned from the field data. For patterns that were devoid of sample sites, classes of terrain approach angle and step height were estimated through photo-interpretation techniques. Class values for each pattern were then extrapolated to similar or equivalent air-photo patterns, and the factor maps were drawn. Figs. 11 and 12 are terrain approach-angle and step-height factor maps, respectively, for a portion of the Baumholder study area.

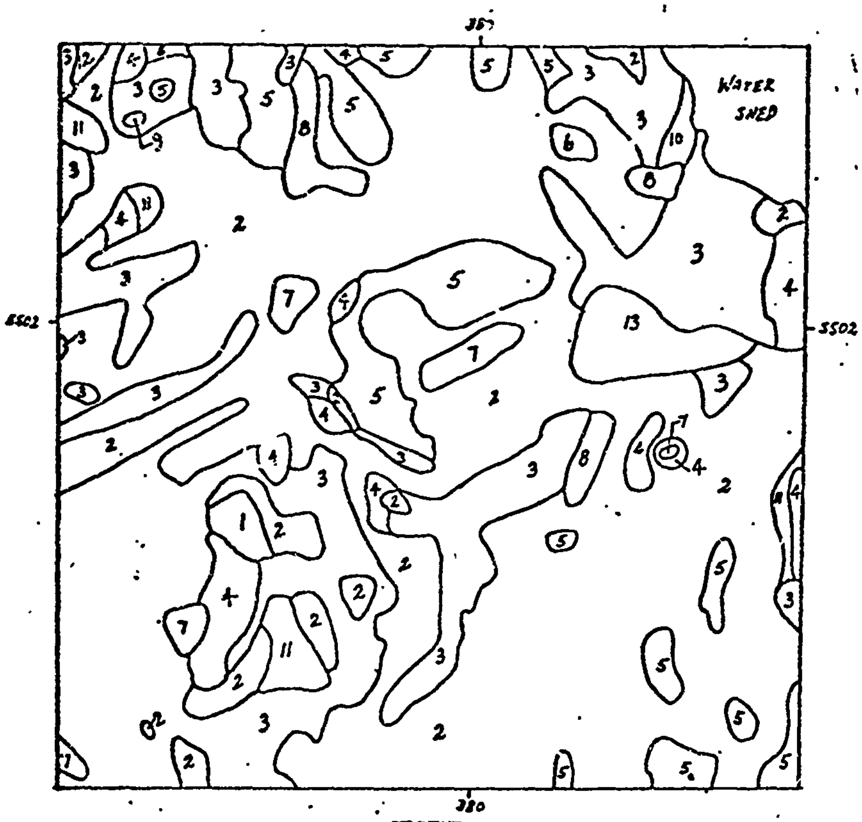
60. Compilation of factor-family maps. Presentation of separate maps for each of the surface geometry factors would have imposed problems in evaluating surface geometry characteristics in each specific area of interest. To eliminate these problems, it was found to be both feasible and desirable to synthesize all of the factors into a single map. This synthesis was simply a process involving sequential superpositioning of the



<u>LEGEND</u>

Map Unit	Spacing ft
1	0 - 50
2	>50 - 150
3	>150 - 225
4	>225

Fig. 10. Obstacle-spacing factor map - Baumholder



LEGEND

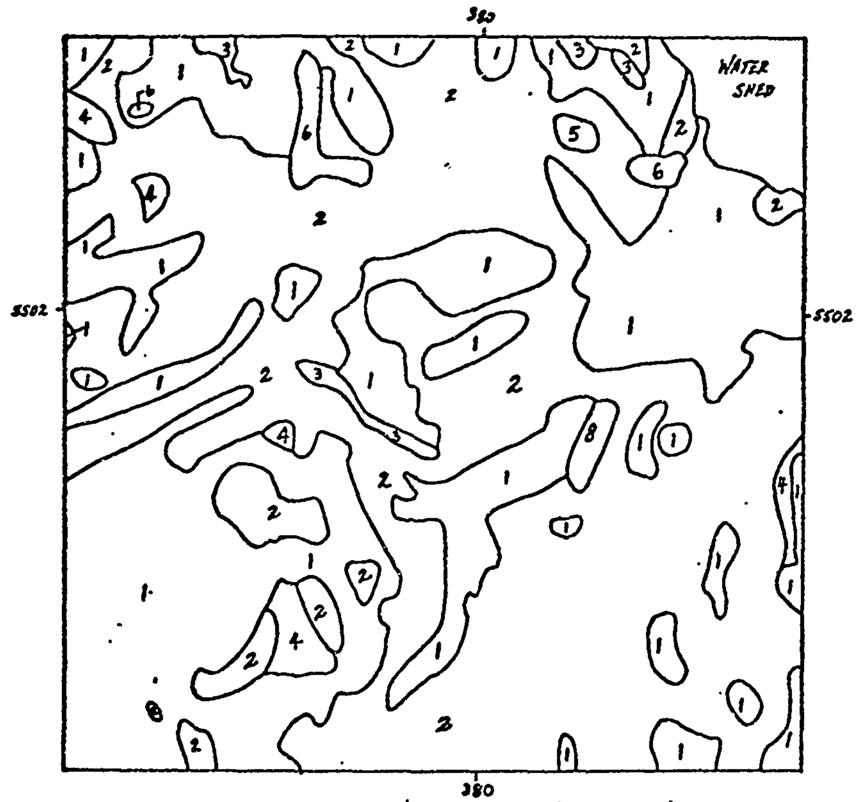
Map Unit*	Approach Angle ** EA	IA
1	1/1	10/10
2	2/2	4/4
3	2/2	5/5
4	2/2	10/10
5	2/3	3/4
6	2/7	6/9
7	3/2	10/10
8	3/3	6/6
9	3/3	9/9
10	4/4	4/4
11	4/4	10/10
12	5/5	5/5
13	7/4	10/10

*Each map unit represents an array of two fractional symbols (i.e. 1/1 10/10) indicating mapping classes of exterior (EA) and interior (IA) approach angle. The numerator of the fraction indicates class ranges that will be encountered while traversing an area in an easterly direction (i.e. azimuth from >0 to 180 deg) and the denominator refers to a westerly direction (i.e. azimuth from >180 to 360 deg), assuming that the vehicle intersects the feature at a right angle.

**Mapping class ranges of the approach angles are:

Mapping Class	Range deg	Mapping Class	Range deg
1	0-1.5	6	>22-27
2	>1.5-4.5	7	>27-31
3	>4.5-10	8	>31-36
4	>10-17	9	>36-45
5	>17-22	10	>45

Fig. 11. Approach angle-factor map - Baumholder



LEGEND

Map Unit*	Step Height**
1	1/1
2	2/2
3	3/3
4	5/5
5	8/7
6	8/8

*Each map unit represents a fractional symbol (i.e. 1/1) indicating a mapping class of step height. The numerator of the fraction indicates class ranges that will be encountered while traversing an area in an easterly direction (i.e. azimuth from >0 to 180 deg) and the denominator refers to a westerly direction (i.e. >180 to 360 deg) assuming that the vehicle intersects the feature at a right angle.

**Mapping class ranges of step height are:

Mapping Class	Range in
1	<8
2	8-10
3	>10-12
4	>12-14
5	>14-16
6	>16-20
7	>20-30
8	>30

Fig. 12. Step height-factor map - Baumholder

four factor maps. To assure uniformity, the maps were always superposed in the following sequence: slope, spacing of vertical obstacles, terrain approach angle, and step height.

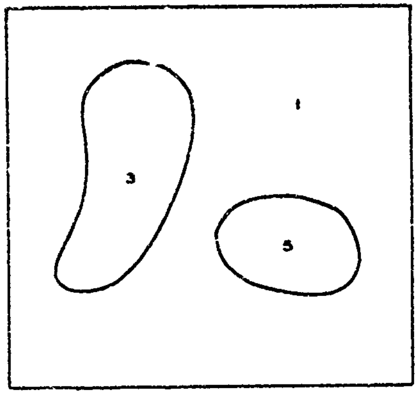
The basic process was as follows:

a. One of the factor maps was selected as a datum. In this example, the slope class map (fig. 13a) was chosen. The factor classes occurring on that map were tabulated (see sheet 2 of fig. 13).

b. A second factor map (in this case, the vertical obstacle spacing maps) was chosen and superposed on the datum map, as shown in fig. 13b. All combinations of classes of the two factors that occur on the combined map are tabulated (sheet 2 of fig. 13). Note that in the tabulation the first digit position indicates the class of the datum map (in this case, slope) and the second digit indicates the class of the superposed map (in this case, vertical obstacle spacing).

c. A third factor map (terrain approach angle map in the example) was chosen and superposed on the combined map shown in fig. 13b. The result of this combination is shown in fig. 13c. The factor combinations were recorded (sheet 2 of fig. 13) as before.

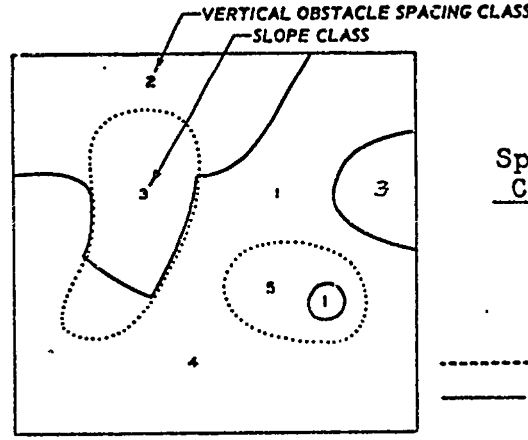
d. This process was repeated as many times as there were factor maps in the set; in this example, one more time for step height (fig. 13d). Note in sheet 2 of fig. 13 that each map unit is now identified by an array of four numbers (e.g. 1, 2,3,3) representing the map classes of slope, spacing of



LEGEND

Slope Class	Range deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31

a. SLOPE CLASS MAP



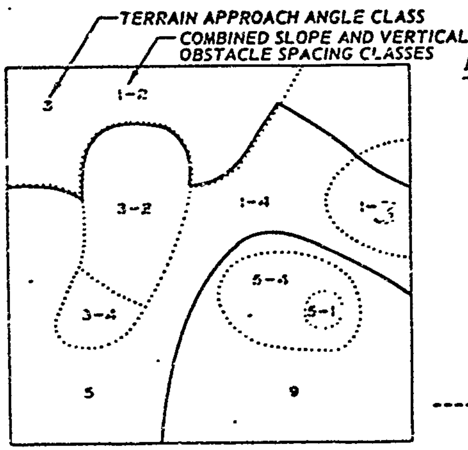
LEGEND

Spacing Class	Range ft
1	0-50
2	> 50-150
3	> 150-225
4	> 225

-------- BOUNDARY OF SLOPE CLASSES

———— BOUNDARY OF VERTICAL OBSTACLE SPACING CLASSES

b. VERTICAL OBSTACLE SPACING CLASS MAP SUPERPOSED ON SLOPE CLASS MAP



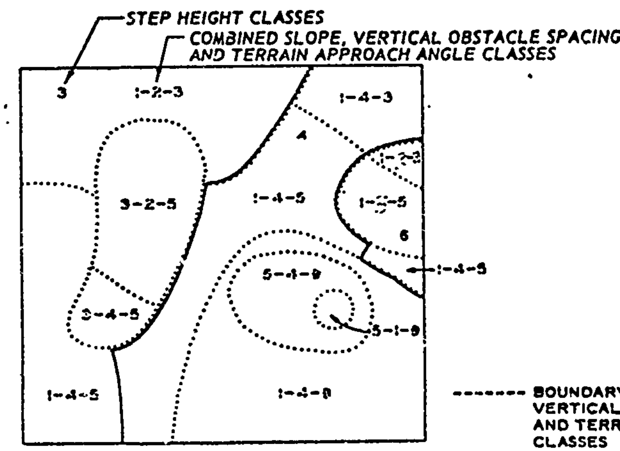
LEGEND

Terrain Approach Angle Class	Range deg
1	0-1.5
2	> 1.5-4.5
3	> 4.5-10
4	> 10-17
5	> 17-22
6	> 22-27
7	> 27-31
8	> 31-36
9	> 36-45
10	> 45

-------- BOUNDARY OF COMBINED SLOPE AND VERTICAL OBSTACLE SPACING CLASSES

———— BOUNDARY OF TERRAIN APPROACH ANGLE CLASSES

c. TERRAIN APPROACH ANGLE SUPERPOSED ON COMBINED SLOPE CLASS AND VERTICAL OBSTACLE SPACING CLASS MAP



LEGEND

Step Height Class	Range in
1	< 8
2	8-10
3	> 10-12
4	> 12-14
5	> 14-16
6	> 16-20
7	> 20-30
8	> 30

-------- BOUNDARY OF COMBINED SLOPE, VERTICAL OBSTACLE SPACING, AND TERRAIN APPROACH ANGLE CLASSES

———— BOUNDARY OF STEP HEIGHT CLASSES

d. STEP HEIGHT SUPERPOSED ON COMBINED SLOPE CLASS, VERTICAL OBSTACLE SPACING, AND TERRAIN APPROACH ANGLE CLASS MAP

Fig. 13 Process used to compile a factor-family map (sheet 1 of 2)

PHASE OF PROCESS	COMBINATIONS OF FACTOR VALUE CLASSES
FIG. 13a	SLOPE CLASSES ON FIRST MAP:
	1 3 5
FIG. 13b	COMBINATIONS OF SLOPE AND VERTICAL OBSTACLE SPACING CLASSES ON MAP:
	SLOPE CLASS VERTICAL OBSTACLE SPACING CLASS
	1,2 3,2 5,1 1,3 3,4 5,4 1,4
FIG. 13c	COMBINATIONS OF SLOPE, VERTICAL OBSTACLE SPACING, AND TERRAIN APPROACH ANGLE CLASSES ON MAP:
	SLOPE CLASS VERTICAL OBSTACLE SPACING CLASS TERRAIN APPROACH ANGLE CLASS
	1,2,3 3,2,5 5,1,9 1,3,3 3,4,5 [illegible] 1,3,5 1,4,3 1,4,5 1,4,9
FIG. 13d	COMBINATIONS OF SLOPE, VERTICAL OBSTACLE SPACING, TERRAIN APPROACH ANGLE, AND STEP HEIGHT CLASSES ON MAP:
	SLOPE CLASS VERTICAL OBSTACLE SPACING CLASS TERRAIN APPROACH ANGLE CLASS STEP HEIGHT CLASS
	1,2,3,3 3,2,5,3 5,1,9,4 1,3,3,6 3,4,5,3 5,4,9,4 1,3,5,6 1,4,3,4 1,4,5,3 1,4,5,4 1,4,5,6 1,4,9,4
	COMPILATION OF UNITS FOR FACTOR-FAMILY MAPS

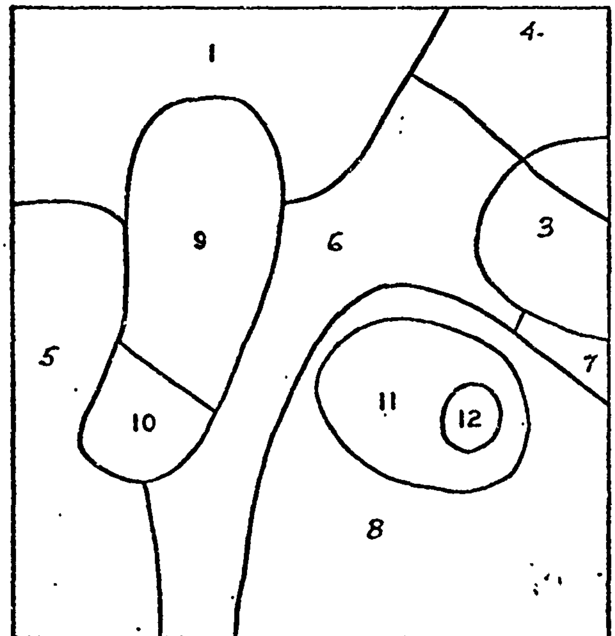
Fig. 13 (sheet 2 of 2)

vertical obstacles, terrain approach angle, and step height, in that order from left to right.

e. This tabulation (sheet 2 of fig. 13) was the basis for the legend for a combined map, which is called a factor-family map. The factor-family map derived from the example is presented in fig. 14. Each discrete combination of factor-value classes was assigned a single code number, as indicated in the legend of the sample map in fig. 14. The code numbers were used as symbols to identify areas on the map; such areas are called factor-family types. Fig. 15 illustrates the surface geometry factor-family map compiled by superposing the four surface geometry factor maps (figs. 9-12) of a portion of the Baumholder study area.

Surface composition

61. The surface composition factor of relevance to vehicular mobility mapped in this study was soil mass strength, identified in terms of RCI or CI depending upon grain size of soil and organic content. This factor was mapped through interpretation of air photos using criteria derived from associations of strength measurements with soil type, topographic position, depth to bedrock, drainage characteristics, and land use. Because this factor was mapped at only the moisture conditions that were encountered during the field sampling, only one map was prepared for the surface composition factor family; therefore, the soil mass strength-factor map was also the surface composition factor-family map, and no superpositioning of maps was required. There were 20 surface composition map units in the three Germany study areas. Fig. 16 is a surface composition factor-family



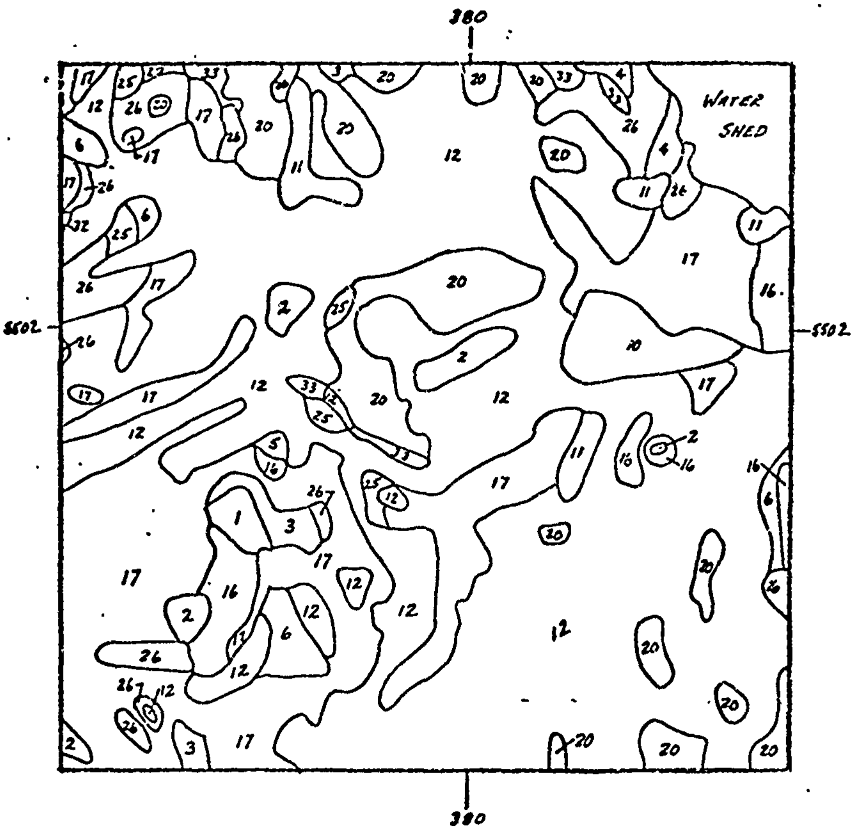
LEGEND

MAP UNIT	SL	OS	AA*	SH*
1	1	2	3	3
2	1	3	3	6
3	1	3	5	6
4	1	4	3	4
5	1	4	5	3
6	1	4	5	4
7	1	4	5	6
8	1	4	9	4
9	3	2	5	3
10	3	4	5	3
11	5	1	9	4
12	5	4	9	4

SL = SLOPE CLASS
OS = VERTICAL OBSTACLE SPACING CLASS
AA = APPROACH ANGLE CLASS
SH = STEP HEIGHT CLASS

* NOTE THAT IN PLATES 3 AND 4, THESE ARE GIVEN AS "FRACTIONS"; APPROACH ANGLES FACING NORTH AND EAST ARE GIVEN AS THE "NUMERATOR"; APPROACH ANGLES FACING SOUTH AND WEST ARE GIVEN AS THE "DENOMINATOR." SEE VOLUME III OF THIS SERIES OF REPORTS FOR DETAILS.

Fig. 14. Factor-family (surface geometry) map and legend



LEGEND (partial)

Map Unit*	Slope**	Spacing	Approach Angle EA	Approach Angle IA	Step Height
2	1	1	3/2	10/10	1/1
10	2	1	7/4	10/10	1/1
20	3	4	2/3	3/4	1/1

*Each map unit represents an array of four symbols [i.e. 1,1,(3/2 10/10), 1/1] indicating mapping classes of slope, obstacle spacing, approach angle (EA and IA) and step height. Fractional designations indicate that dual classes were mapped. The numerator of the fraction indicates class range that will be encountered while traversing an area in an easterly direction (i.e. azimuth from >0 to 180 deg) and the denominator refers to a westerly direction (i.e. azimuth from >180 to 360 deg) assuming that the vehicle intersects the obstacle at a right angle.

**Mapping class ranges of each surface geometry factor are:

Slope

Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31

Spacing

Map Class	ft
1	0-50
2	>50-150
3	>150-225
4	>225

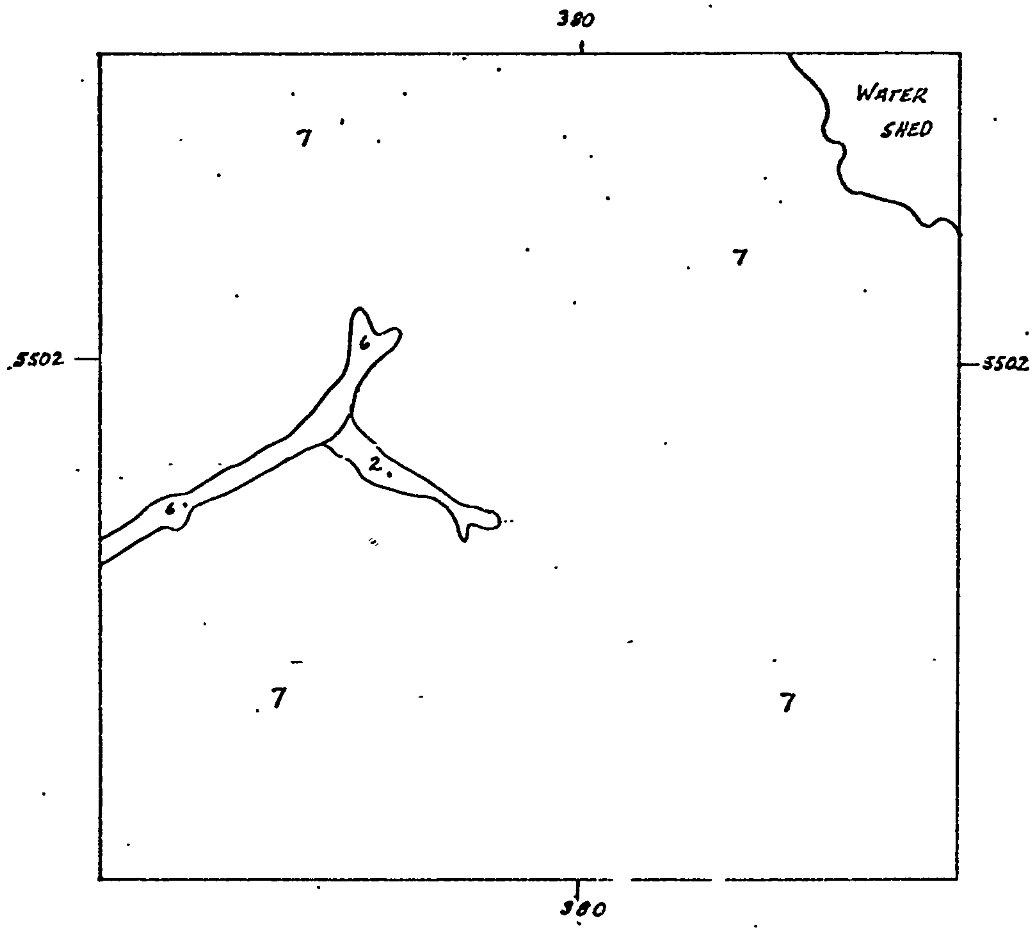
Approach Angle

Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45

Step Height

Map Class	in
1	<8
2	8-10
3	>10-12
4	>12-14
5	>14-16
6	>16-20
7	>20-30
8	>30

Fig. 15. Surface geometry factor-family map - Baumholder



LEGEND

Map Unit	Range 6 - 12 in. RCI
*1	0 - 10
2	>10 - 20
*3	> 20 - 35
*4	> 35 - 50
*5	> 50 - 75
6	>75 - 125
7	>125

* Units not on this map

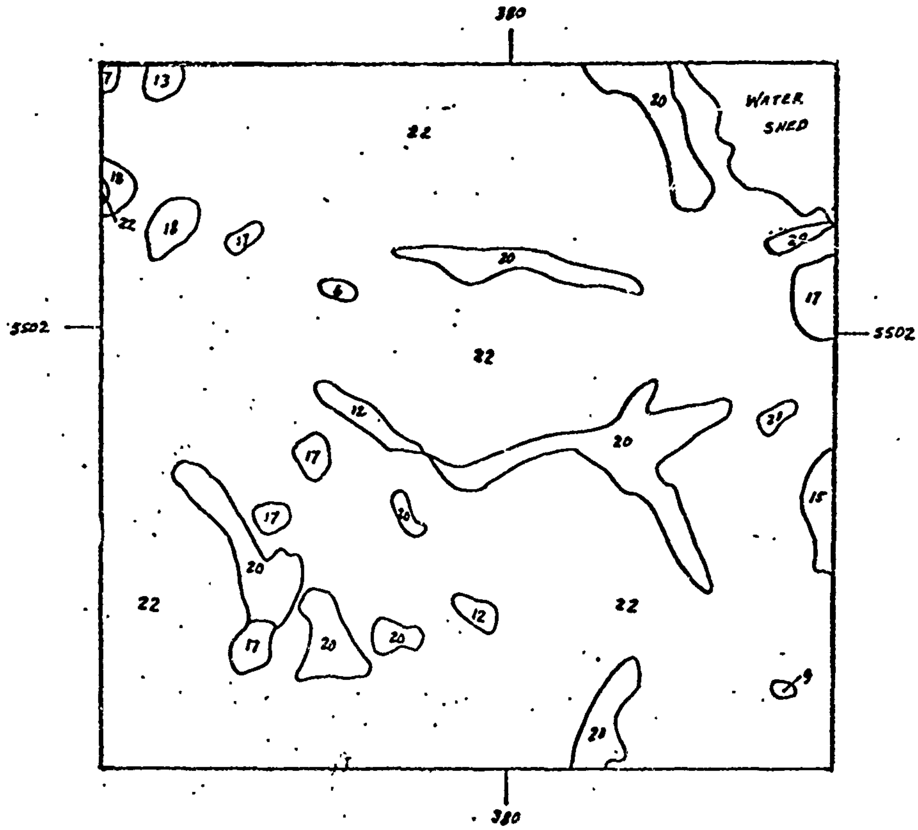
Fig. 16. Surface composition map - Baumholder

map. To identify the soil mass strength along the banks and bed of hydrologic geometry features, a linear surface composition map was prepared. Soil conditions along these features were identified on the aerial photographs using principally the soil data collected along the hydrologic geometry profiles and the areal surface composition factor-family maps. This map was actually prepared in conjunction with the hydrologic geometry factor-family map.

Vegetation

62. The stem diameter, stem spacing, and visibility factor maps were prepared by interpretation of air photos. Air-photo patterns where actual ground data were collected at sample sites were assigned appropriate class values, and these values were then extrapolated to similar photo patterns. Distinctive air-photo patterns devoid of ground data were assigned vegetation factor values using photo-interpretation keys developed during this study. Once type patterns had been identified, similar air-photo patterns could be assigned like identification by the judicious use of the keys.

63. Once vegetation factor classes had been delineated on the photomosaics, these delineations and identifications were transferred to the final 1:25,000 base maps. The method of synthesizing the eight factor maps into a factor-family map was similar to that discussed for surface geometry (paragraph 60). The resulting map has an eight-digit array within each outlined area. The first seven digits identify the spacing classes of stems with appropriate diameters >1, 2.5, 4, 5.5, 7, 8.5, and 10 in., and the last digit represents the visibility class. A tabulation of each discrete combination was prepared for each study area described in paragraph . Fig. 17 is a final vegetation factor-family map.



LEGEND

Map Unit	Vegetation: Spacing of Stems > The Specified Diameter, in.							Visibility
	1.0	2.5	4.0	5.5	7.0	8.5	10.0	
6	1	1	7	7	7	7	7	7
7	1	2	2	3	5	7	7	7
9	2	2	2	2	3	5	7	7
12	2	3	3	4	4	5	5	7
13	2	3	4	4	5	7	7	7
15	4	4	4	4	4	4	4	7
17	4	4	4	4	4	5	5	7
18	4	4	4	4	4	7	7	7
20	6	6	6	6	6	6	6	7
22	7	7	7	7	7	7	7	7

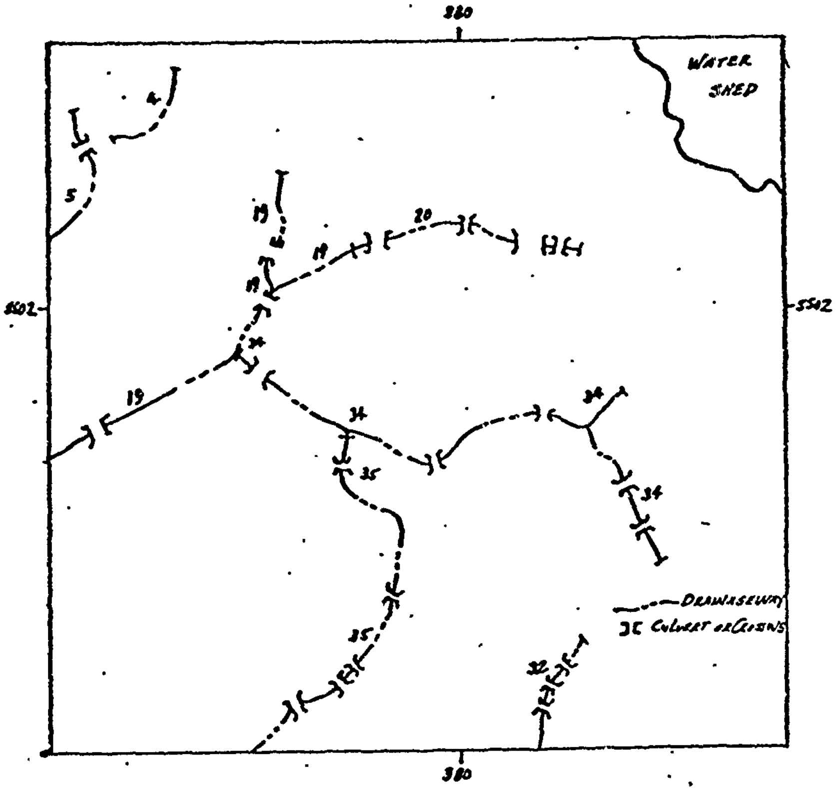
Map Class	Stem Spacing, ft	Visibility, ft
1	0 - 8	<15
2	>8 - 12	15 - 21
3	>12 - 15	>21 - 27
4	>15 - 20	>27 - 33
5	>20 - 25	>33 - 39
6	>25 - 30	>39 - 45
7	>30	>45

Fig. 17. Vegetation factor-family map - Baumholder

Hydrologic geometry

64. The individual hydrologic geometry features were mapped through stereoscopic examination of the air photos. One or a combination of the following sources of information was used to establish class ranges for the factors within each distinctive air photo pattern: Field measurements, topographic maps, ground photographs, personal observations of the areas, and background knowledge of hydrologic principles. The first step was to prepare a base map with all of the hydrologic features. The water depth map was then prepared whereby every segment of the stream network was identified in terms of a class range for water depth. The map was prepared first because the ≤ 3 ft and ≥ 3 ft water depth of hydrologic geometry features have a bearing on the step height measurements and whether a position of step base is mapped. After all of the hydrologic geometry factor maps were prepared, they were synthesized into a factor-family map. The method of synthesizing was similar to that discussed for surface geometry except that lines were subdivided instead of areas. The resulting map has a seven-digit array of numbers for each segment of the stream network. A tabulation of each discrete combination was prepared for each study area by the method described in paragraph 60.

65. Linear surface geometry features were portrayed on the same map and were identified in terms of step height and interior and exterior approach angles on both sides of the feature. To simplify and alleviate serious cartographic problems, both characteristics were identified by a single number. Numbers were assigned numerically to the stratified surface geometry combination beginning with a number greater than the maximum number assigned to the hydrologic geometry combination. Fig. 18 is a



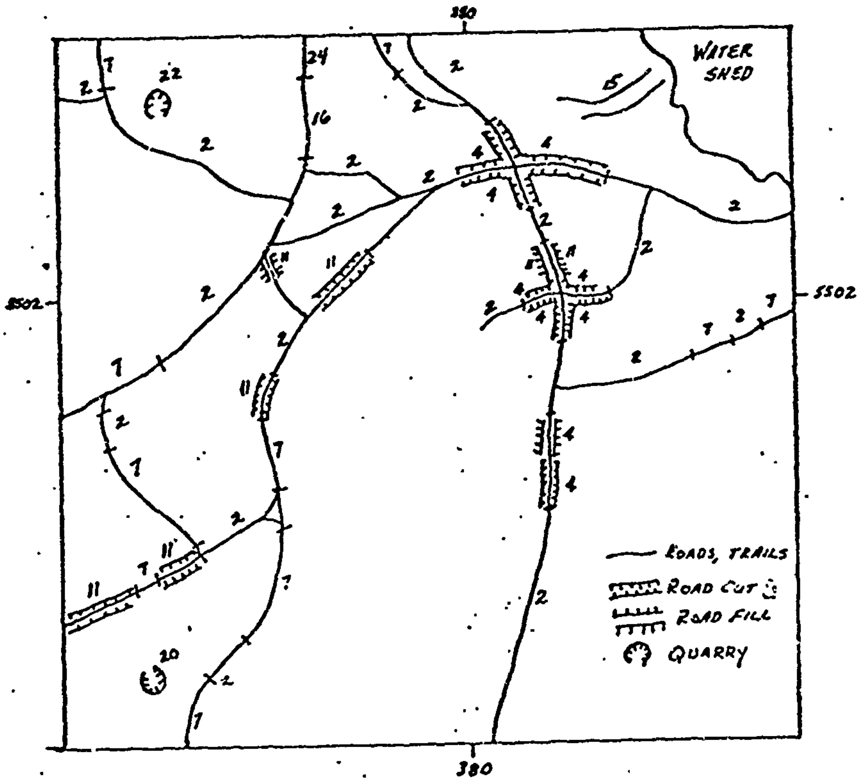
LEGEND

Map Unit	WEST BANK EA	IA	SH	PS	EAST BANK EA	IA	SH	PS	STREAM Width	Depth	SOIL CI 6 - 12 in
4	1	10	8	-	1	1	8	-	1	1	6
5	1	10	8	-	1	10	8	-	1	1	7
19	2	10	7	-	3	10	8	-	1	1	6
20	2	10	8	-	3	10	8	-	2	1	6
32	4	5	8	-	4	10	5	-	1	1	5
34	4	8	8	-	2	7	8	-	1	1	5
35	5	10	5	-	4	10	6	-	1	1	5

Map Class	Approach Angle EA & IA	Step Height in	Stream Width ft	Stream Depth ft	Fine-Grained Soil
1	0 - 1.5	<8			0 - 20
2	>1.5 - 4.5	8 - 10	0 - 5	<3	>20 - 40
3	>4.5 - 10	>10 - 12	>5 - 10	3 - 4.5	>40 - 75
4	>10 - 17	>12 - 14	>10 - 15	>4.5 - 15	>75 - 125
5	>17 - 22	>14 - 16	>15 - 20	>15	>125 - 175
6	>22 - 27	>16 - 20	>20 - 25		>175 - 250
7	>27 - 31	>20 - 30	>25 - 30		>250
8	>31 - 36	>30	>30		
9	>36 - 45				
10	>45				

Fig. 18. Hydrologic geometry factor-family map - Baumholder

hydrologic geometry factor-family map of a portion of the Baumholder study area. Fig. 19 is an example of a linear surface geometry map of a portion of Baumholder.



LEGEND (partial)

Map Unit	Slope	Spacing	Approach Angle EA	IA	Step Height
2	2	4	* 2/2	7/7	5/5
11	3	4	3/3	9/9	8/8
22	4	4	7/7	10/10	8/8

Map Class	Slope deg	Spacing ft	Approach Angle EA-IA deg	Step Height in
1	0-1.5	0-50	0-1.5	<8
2	>1.5-4.5	>50-150	>1.5-4.5	8-10
3	>4.5-10	>150-225	>4.5-10	>10-12
4	>10-17	>225	>10-17	>12-14
5	>17-22		>17-22	>14-16
6	>22-27		>22-27	>16-20
7	>27-31		>27-31	>20-30
8	>31		>31-36	>30
9			>36-45	
10			>45	

*Fractional designations indicate that dual classes were mapped. The numerator of the fraction indicates class ranges that will be encountered while traversing an area in an easterly direction (i.e. azimuth from >0 to 180 deg) and the denominator refers to a westerly direction (i.e. azimuth from >180 to 360 deg), assuming that the vehicle intersects the feature at a right angle.

Fig. 19. Linear surface geometry factor-family map - Baumholder

PART V: CONSTRUCTION OF FACTOR-COMPLEX MAPS

66. Factor-complex maps represent the final synthesis of the factors of the four families that describe terrain. Figure 20 diagrammatically

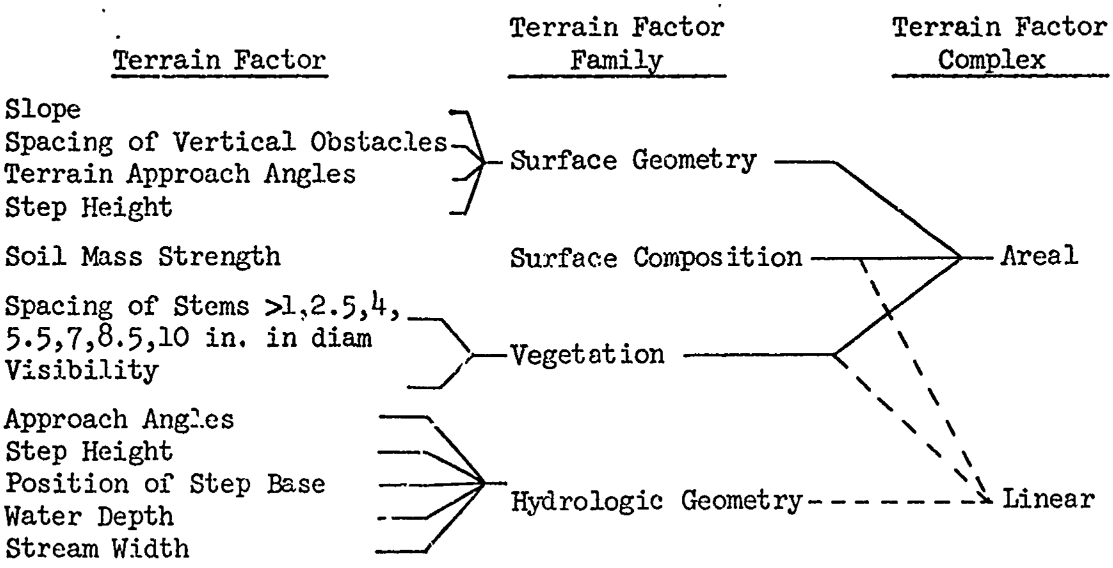


Fig. 20. Construction of terrain factor-complex maps

shows the various factors of both areal and linear factor complexes and the sequence in which they are combined. Because of mapping scale, features on the hydrologic geometry factor-family maps are almost entirely portrayed as a single line that indicates the planimetric position of the hydrologic feature (e.g., a segment of a stream or canal, or the shore of a lake), and the factors characterizing that feature are annotated by a symbol beside it. On the other hand, the surface geometry, surface composition, and vegetation factors could almost always be portrayed as areas. Therefore, to avoid the cartographic confusion that would result from mixing areal and linear designations on the same map, two different factor-complex maps are compiled. Areal factor-complex maps are composed of surface geometry, vegetation, and surface composition factor combinations,

and linear factor-complex maps are composed of hydrologic geometry, vegetation, and surface composition factor combinations.

Terrain Factor-Complex Map

Areal

67. An areal factor-complex map is a composite of the surface geometry, surface composition, and vegetation factor-family maps. Surface geometry was considered first in the compilation sequence mainly because of the natural variation and the control that it exerts over the remaining two factor families in the evolution of the terrain. Further, surface geometry features appear to exert the major impedances to vehicle passage, with the other two factor families exerting effects of only secondary importance. The sequence for consideration of the remaining factor-family maps in the final compilation of the factor-complex maps was largely arbitrary. However, it was found to be more convenient first to combine the surface composition map with the surface geometry map, and then superpose the vegetation map. The methods used are discussed in the following paragraphs.

68. A transparent copy of a surface geometry factor-family map was used as a base for an areal factor-complex map. Areas outlined on this map were identified by numbers ranging from 1 to 26, the latter being the number of variations in surface geometry factor combinations (i.e., surface geometry factor-family units) mapped in Baumholder. These numbers identified the four-number arrays representing class values of characteristic slope, vertical obstacle spacing, terrain approach angle, and step height (see table 1).

69. The surface composition map was then superposed on the surface

geometry map, and all lines that did not coincide with the lines on the surface geometry map were transcribed. Every outlined area was then identified by two numbers or number designations, the first of which represents a map unit of surface geometry and the second, a map unit of surface composition. For example, the designation (10,7) indicates a map unit of 10 for surface geometry and a map unit of 7 for surface composition.

70. The vegetation map was the last to be superposed on the base map. All lines on the vegetation map that were not coincident with the lines on the factor-complex base map were transcribed to the base map, and the resulting areas were identified by three numbers or number designations representing map units of surface geometry, surface composition, and vegetation, always in that order. For example, in the designation (10,7,22), 10 identifies the surface geometry map unit; 7 identifies the surface composition unit; and 22 identifies the vegetation unit. It will be noted that this process is similar to that used in the compilation of individual factor-family maps.

71. Areal factor-complex maps were prepared of the three study areas. The three-number arrays identifying individual factor complexes on these maps were replaced by single-number designations keyed to the map units of surface geometry, surface composition, and vegetation, always in that order. When the above array 10,7,22, is grouped numerically, the number 56 shown on the areal factor-complex map represents the array 10,7,22. The total number of different combinations resulting from combinations of these three factor families was 918 for the three study areas. No final legend containing these 918 entries, together with their constituent

factor-value classes, was prepared; instead, individual legends were prepared for each reservation.

72. Plates 1-3 are areal factor-complex maps of Baumholder, Bergen-Hohne, and Grafenwohr, respectively. The following is the total number of areal factor complexes mapped in each reservation: Baumholder 248, Bergen-Hohne 339, and Grafenwohr 331.

Linear

73. The linear factor-complex map is a composite of hydrologic geometry, surface composition, and vegetation factor-family maps. Also shown on this map are the linear surface geometry features (i.e. quarries, escarpments, and road and embankments) and their associated surface composition and vegetation values. The linear factor-complex map was prepared in a manner similar to that used for the areal type.

74. A transparent copy of the hydrologi geometry factor-family map was used as the base for the linear factor-complex map (fig. 18). This transparent base was first superposed on the linear surface composition factor-family map, units occurring in combination with each hydrologic geometry unit were then determined, and the identifying designation affixed to the related hydrologic geometry unit. For example, a segment might be identified by the combination (32,7), where the 32 identifies the hydrologic geometry map unit, and the 7 identifies the surface composition unit. Where the surface composition changed within a segment identified on the hydrologic geometry map, a tick mark was drawn across the line indicating the hydrologic geometry feature, and each new segment was identified by the proper hydrologic geometry and surface composition map unit.

75. The transparent overlay containing synthesized combinations of

hydrologic geometry and surface composition was then superposed on the vegetation map, the last factor-family map to be synthesized in the development of the linear factor-complex maps. Areas defined by the synthesis of the three factor-family maps were identified by arrays containing combinations of three-number designations, each representing a combination of hydrologic geometry, surface composition, and vegetation factor families, always in that sequence. For example, given a segment or area identified by the combination (32,7,22), the 32 is taken from the hydrologic geometry map, the 7 from the surface composition map, and the 22 from the vegetation map, fig. 17. Vegetation map units that did not coincide with the segments identified on the base map in terms of hydrologic geometry and surface composition required dividing the segment and identifying each new segment with the proper hydrologic geometry, surface composition, and vegetation unit. For surface geometry features, the above procedures were used, only inserting surface geometry units for hydrologic geometry units, and the areal surface composition map was used to identify the surface composition unit.

76. The three-number array was replaced by a single number designation for the final map. When the array described above, 32,7,22, is grouped numerically, the number 53 appearing on the factor complex represents the array of 32,7,22. No master legend was prepared tabulating the 368 linear factor complexes that were mapped in the three reservations, but each reservation was treated separately.

77. Plates 4-6 are linear factor-complex maps of Baumholder, Bergen-Hohne, and Grafenwohr, respectively. The breakdown of linear factor complexes mapped in each reservation are as follows: Baumholder 94, Bergen-Hohne 163, and Grafenwohr 111.

PART VI: MAP VALIDITY AND RECOMMENDATIONS

Map Validity

78. Construction of factor maps and factor-family maps of the study areas furnished the terrain data in the form required by the cross-country speed prediction model for evaluating ground vehicle performance over selected German terrain. Items that influenced the preparation or validity of these maps are as follows:

a. The accuracy of the factor values obtained by photo interpretation was greatly enhanced by the excellent quality and recent age of the air photos.

b. The terrain factor characteristics in the increments required by this study coupled with the photo scale (1:24,000) made practically all direct measurements from the air photos unreliable or impossible.

c. The field measurements of the terrain factors plus the observations made during the field work in areas other than the sampled sites greatly increased the reliability of the air-photo keys established which in turn was reflected on the factor-complex maps.

d. Identifying water depth and soil strength at the moisture conditions during the time of field sampling restricts these characteristics to those specific conditions on the factor-complex maps.

e. Mapping the surface composition characteristics in the stream bed and along the banks resulted in a more

accurate portrayal of the soil strength of these features on the factor-complex maps.

Recommendations

79. A procedure for performing the map compilation routine with automatic data processing (ADP) machines needs to be developed. When done by hand, as reported herein, the process is inordinately time-consuming and therefore expensive. Thus, although the production of factor-complex maps is technically feasible, the process will probably remain impractical for broad military intelligence purposes until a rapid, cheap, and reliable compilation procedure using ADP machines is developed.

80. A procedure should be developed for storing factor maps and factor-complex maps in ADP-compatible digital form (either as punched cards or on magnetic tape) in such fashion that the maps can be reconstructed with a digital plotter at any convenient scale. This capability would obviate the necessity of keeping map sheets on file, would materially increase the general flexibility of the system, and would make it practical to send terrain data to any point by electronic communication systems. The terminal would, of course, require an automatic digital plotter in order to convert the transmitted data to readable form.

81. Any future mapping of terrain for cross-country mobility analysis should include maps that classify the vegetation characteristics along a narrow band (100 m) on both sides of hydrologic geometry features. This will eliminate having to use the areal vegetation maps for the linear

factor-complex map, which in some cases does not indicate the actual vegetation characteristics the vehicle senses upon entering or exiting a hydrologic geometry feature. This would increase the accuracy of the linear factor-complex map.

82. It is recommended that the present program be expanded as follows:

a. Select areas in West Germany outside of military reservations and map the terrain factors so that a wider variety of factor complexes can be included.

b. Initiate programs to collect data on a seasonal basis at selected sites to determine variations of moisture conditions and soil strength, snow cover, and stream depth and velocity.

c. Conduct vehicle tests on military reservations to determine the adequacy of the WES system for describing terrain for ground mobility and to determine the validity of the WES analytical model for predicting vehicle performance.

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Table 1

Class Ranges of Terrain Factors for Ground Mobility

Terrain ctor Family	Terrain Factor	Unit of Measurement	Class Ranges 1	2	3	4	5	6	7	8	9	10
rface geometry	Slope	deg	0-1.5	>1.5-4.5	>4.5-10	>10-17	>17-22	>22-27	>27-31	>31		
	Spacing of vertical obstacles	ft	0-50	>50-150	>150-225	>225						
	Approach angles	deg	0-1.5	>1.5-4.5	>4.5-10	>10-17	>17-22	>22-27	>27-31	>31-36	>36-45	>45
	Step height	in.	<8	8-10	>10-12	>12-14	>14-16	>16-20	>20-30	>30		
rface composition	Soil mass strength											
	fine-grained soils (6-12-in. layer)	RCI	0-10	>10-20	>20-35	>35-50	>50-75	>75-125	>125			
	[1]coarse-grained soils (0-6-in. layer)	CI	0-20	>20-40	>40-75	>75-125	>125-175	>175-250	>250			
	[2]organic soils (6-12-in. layer)	CI	0-15	>15-30	>30-45	>45-60	>60-80	>80				
egetation	Spacing of stems											
	>1 in. in diam	ft	0-8	>8-12	>12-15	>15-20	>20-25	>25-30	>30			
	>2.5 in. in diam	ft	0-8	>8-12	>12-15	>15-20	>20-25	>25-30	>30			
	>4 in. in diam	ft	0-8	>8-12	>12-15	>15-20	>20-25	>25-30	>30			
	>5.5 in. in diam	ft	0-8	>8-12	>12-15	>15-20	>20-25	>25-30	>30			
	>7 in. in diam	ft	0-8	>8-12	>12-15	>15-20	>20-25	>25-30	>30			
	>8.5 in. in diam	ft	0-8	>8-12	>12-15	>15-20	>20-25	>25-30	>30			
	>10 in. in diam	ft	0-8	>8-12	>12-15	>15-20	>20-25	>25-30	>30			
	Visibility	ft	<15	15-21	>21-27	>27-33	>33-39	>39-45	>45			
drologic geometry	Approach angle	deg	0-1.5	>1.5-4.5	>4.5-10	>10-17	>17-22	>22-27	>27-31	>31-36	>36-45	>45
	Step height											
	<3 ft of water	in.	<8	8-10	>10-12	>12-14	>14-16	>16-20	>20-30	>30		
	≥3 ft of water	in.	<12	12-24	>24-36	>36-48	>48					
	Stream width	ft	0-5	>5-10	>10-15	>15-20	>20-25	>25-30	>30			
	Water depth	ft	<3	3-4.5	>4.5-15	>15						
	[4]Position of step base	in.	>48 bwl	>36-48 bwl	>18-36 bwl	1-18 bwl	wl	1-12 awl	>12-30 awl	>30-48 awl	>48 awl	

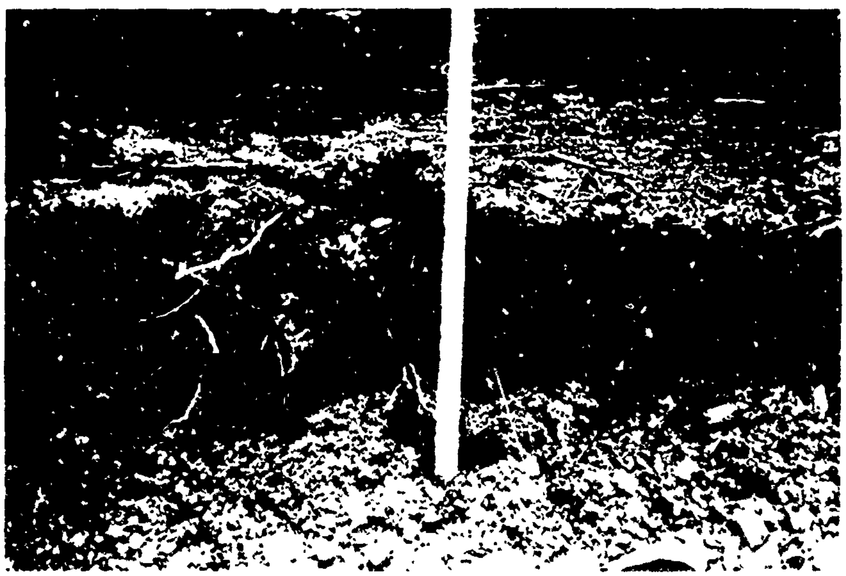
Class range symbols are followed by S (i.e., 1S, 2S, etc.).
Class range symbols are followed by M (i.e., 1M, 2M, etc.).
Class range for each diameter is mapped.

[4] Referenced to water level: bwl - below water level; wl - water level; awl - above water level.

Photograph 1. Rolling terrain in the central portion of the reservation looking south. The town of Baumholder in the background. Located at grid coordinates 797033

Photograph 2. A typical area that has been traversed repeatedly by tracked and wheeled vehicles. The rut depths are small because of shallow soil. Located at grid coordinates 862044

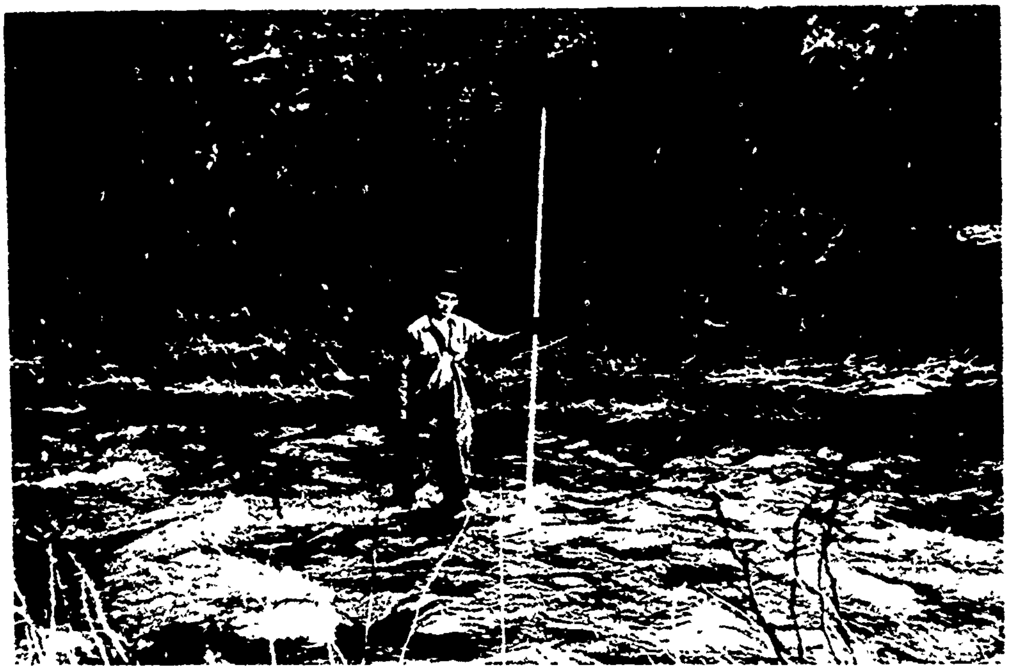
Photograph 3. View of northern portion of the study area looking west. Personnel in foreground collecting soil data. Located at grid coordinates 804046



Photograph 4. Exposed soil profile. Note thin surface mat and the presence of rock fragments. Located at grid coordinates 839042

Photograph 5. A small stand of hardwood, located at grid coordinates 821022

Photograph 6. A uniform stand of evergreens (pine) characterized by small stumps and the absence of low branching. Located at grid coordinates 828025



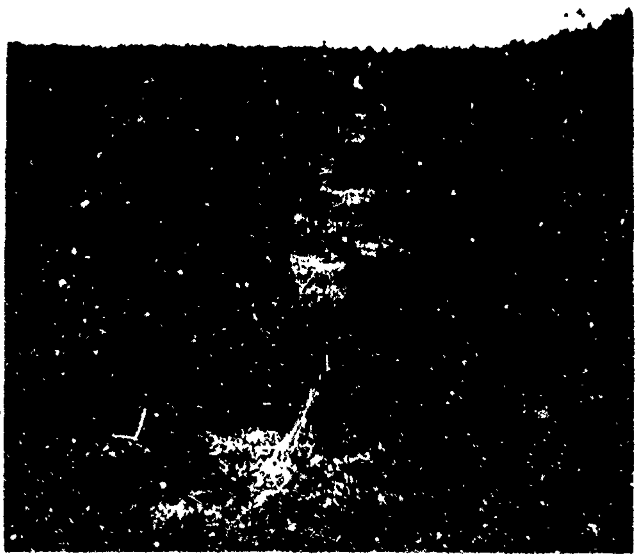
Photograph 7. A major drainageway, located in the southern portion of the study area, flanked by steep slopes. Located at grid coordinates 869965

Photograph 8. Small drainageway in the central part of the reservation looking northwest. Man-made water breaks form small waterfalls along the course. Located at grid coordinates 805997

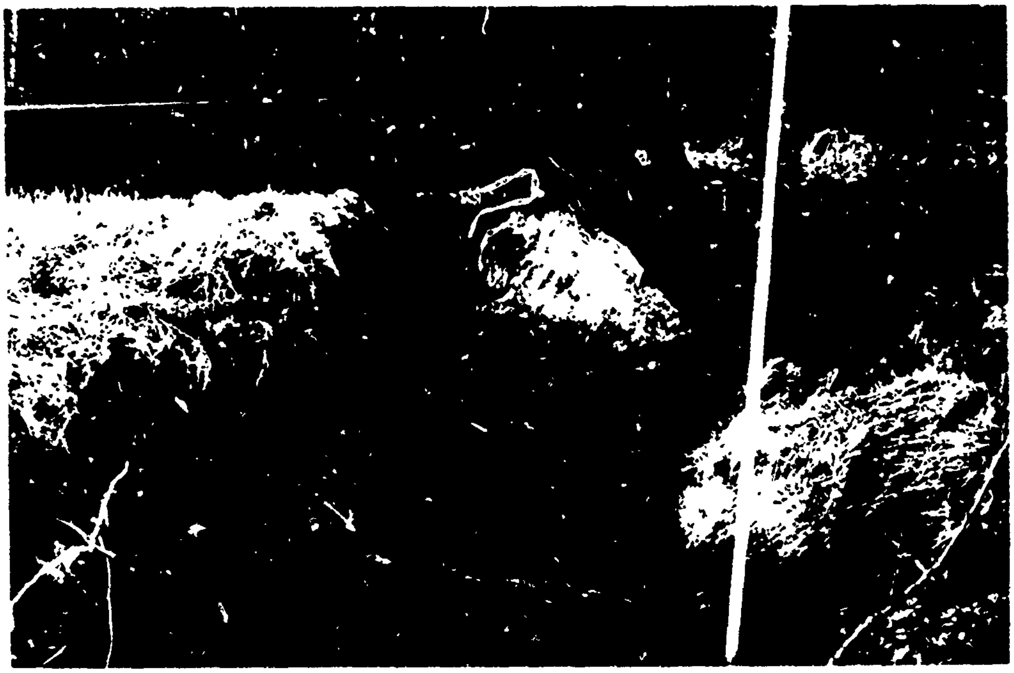
Photograph 9. View of an area of low ridges used as a firing fan. Located at grid coordinates 562499

Photograph 10. Ground-roll effect produced by repeated traffic along a tank trail. Located at grid coordinates 651455

Photograph 11. A uniform stand of pine. Vegetation of this type is common throughout the reservation. Located at grid coordinates 601458



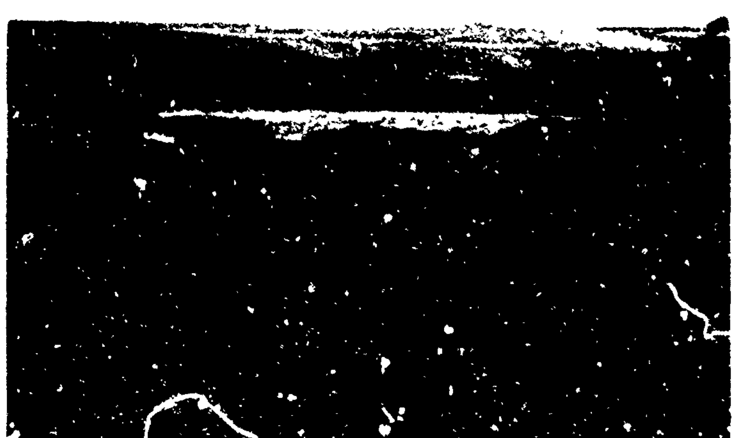
Photograph 12. Planted pines approximately 4 years old. Located at grid coordinates 521478



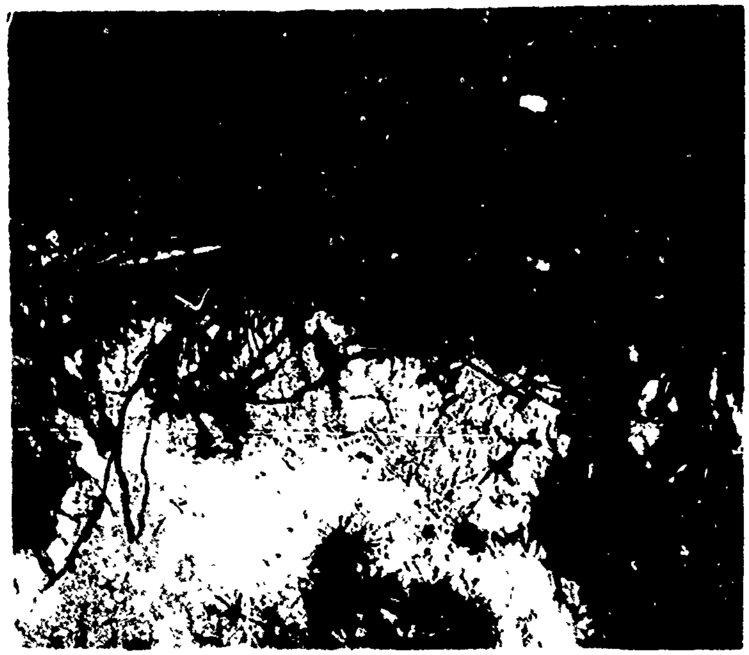
Photograph 13. A natural drainageway with occasional trees along almost vertical banks. Located at grid coordinates 535491

Photograph 14. A man-made drainage canal in a moor. Note the slope of the banks and the alignment of the ditch. Located at grid coordinates 499428

Photograph 15. A general view of a portion of the rolling terrain in the western portion of the reservation looking in a northwest direction. Located at grid coordinates 926071



Photograph 16. Undulating terrain that is void of any pronounced surface expressions or woody vegetation typical of the northwest part of the reservation. Located at grid coordinates 924127



Photograph 17. Exposed soil profile, typical of the vegetated areas, consists of a few inches of decayed grasses and rootlets underlain by fine sand. Located at grid coordinates 126084

Photograph 18. A marsh environment along a natural drainageway. Located at grid coordinates 001026

Photograph 19. A typical stand of pines characterized by the absence of undergrowth. Located at grid coordinates 968012

Photograph 20. An area where all stems have been cut and the reseeding is being done by nature. Note stumps in the foreground. Located at grid coordinates 051038

Photograph 21. A small natural drainageway with low, steep, grass covered banks. Located at grid coordinates 121058

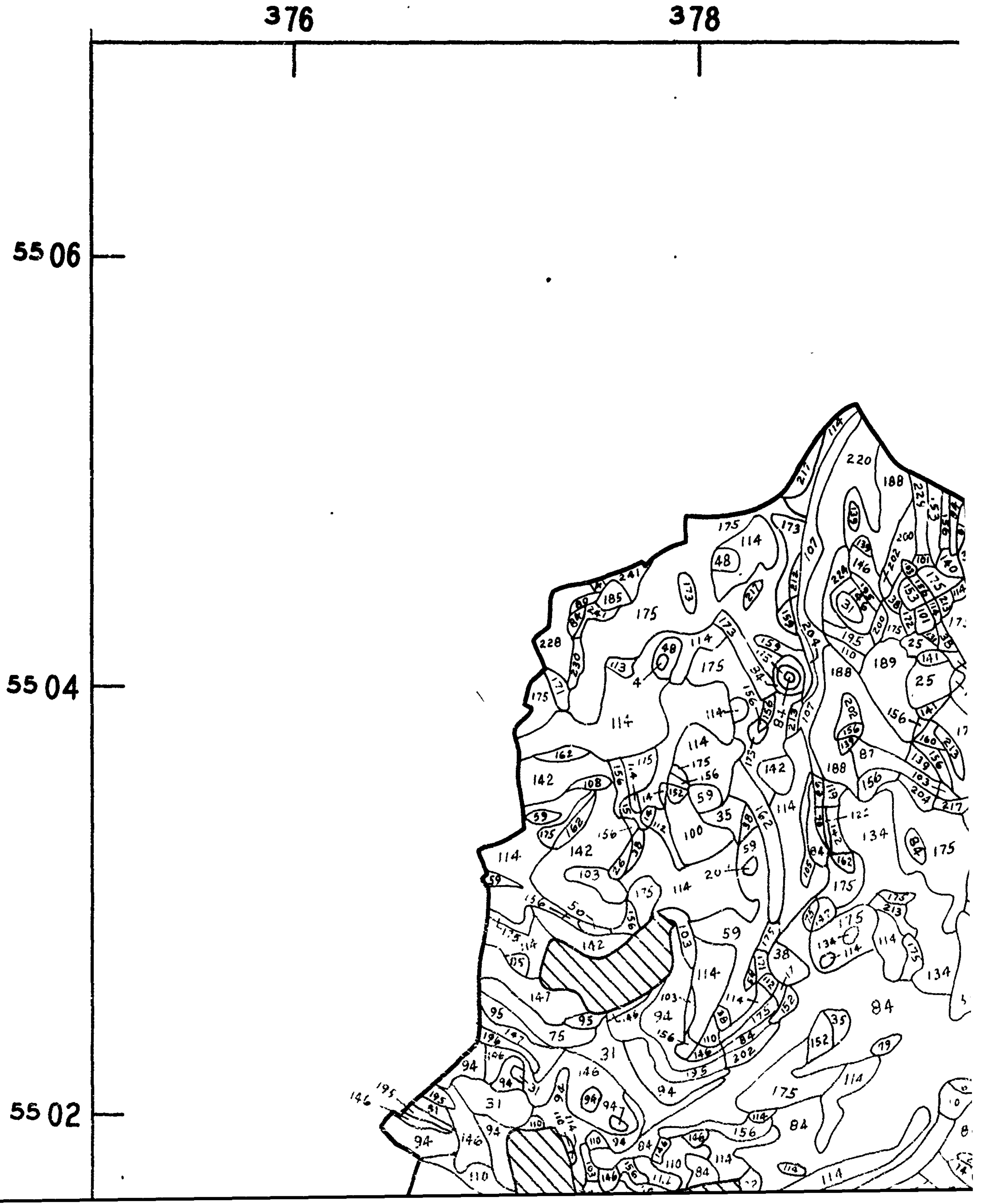
Photograph 22. Man-made lake surrounded by gentle slopes. Water depth is approximately 4 ft at the dam. Located at grid coordinates 041134

APPENDIX A: SUMMARY OF FIELD DATA AND SITE LOCATION MAPS

BAUMHOLDER

1

BAUMHOLDER



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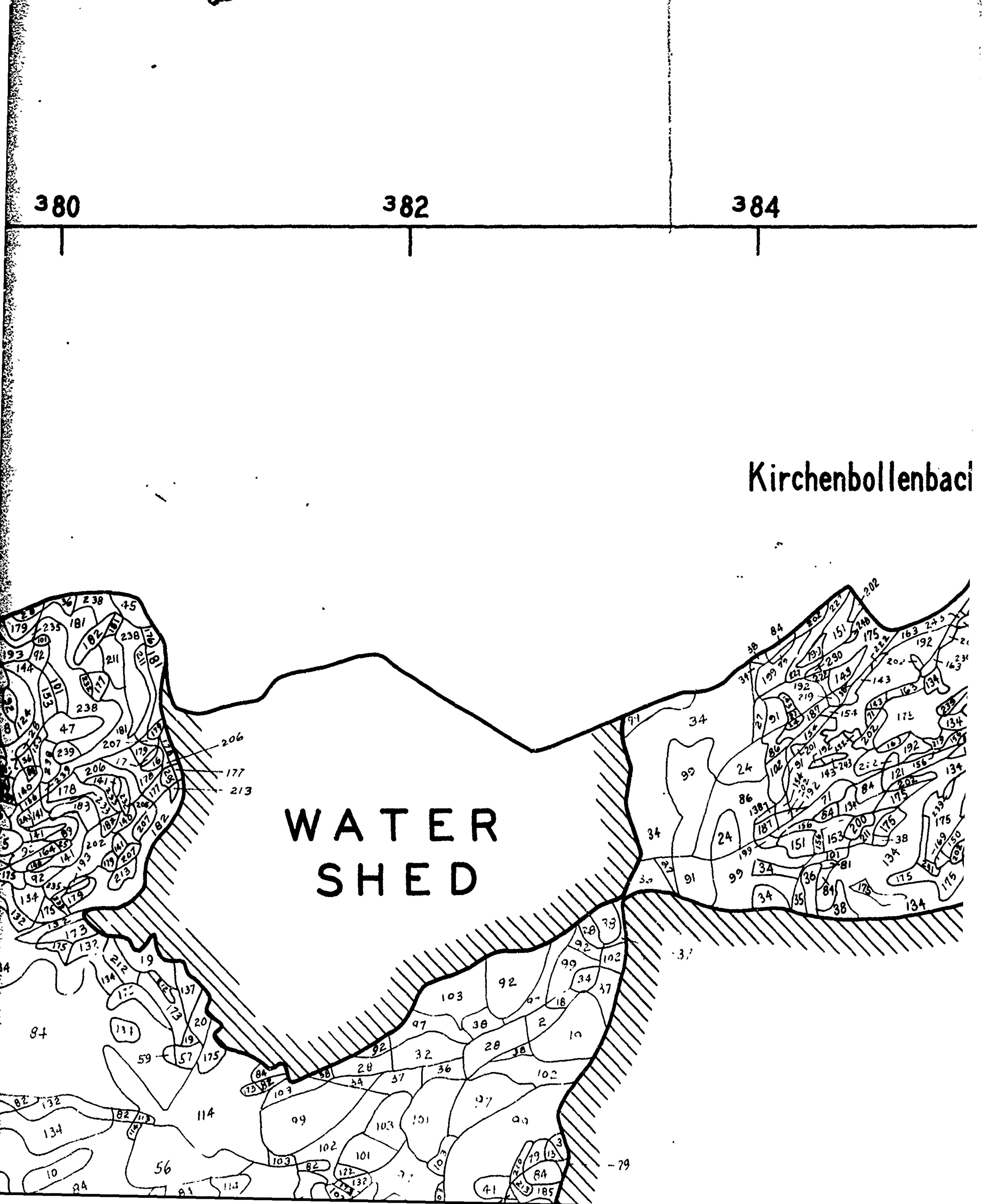

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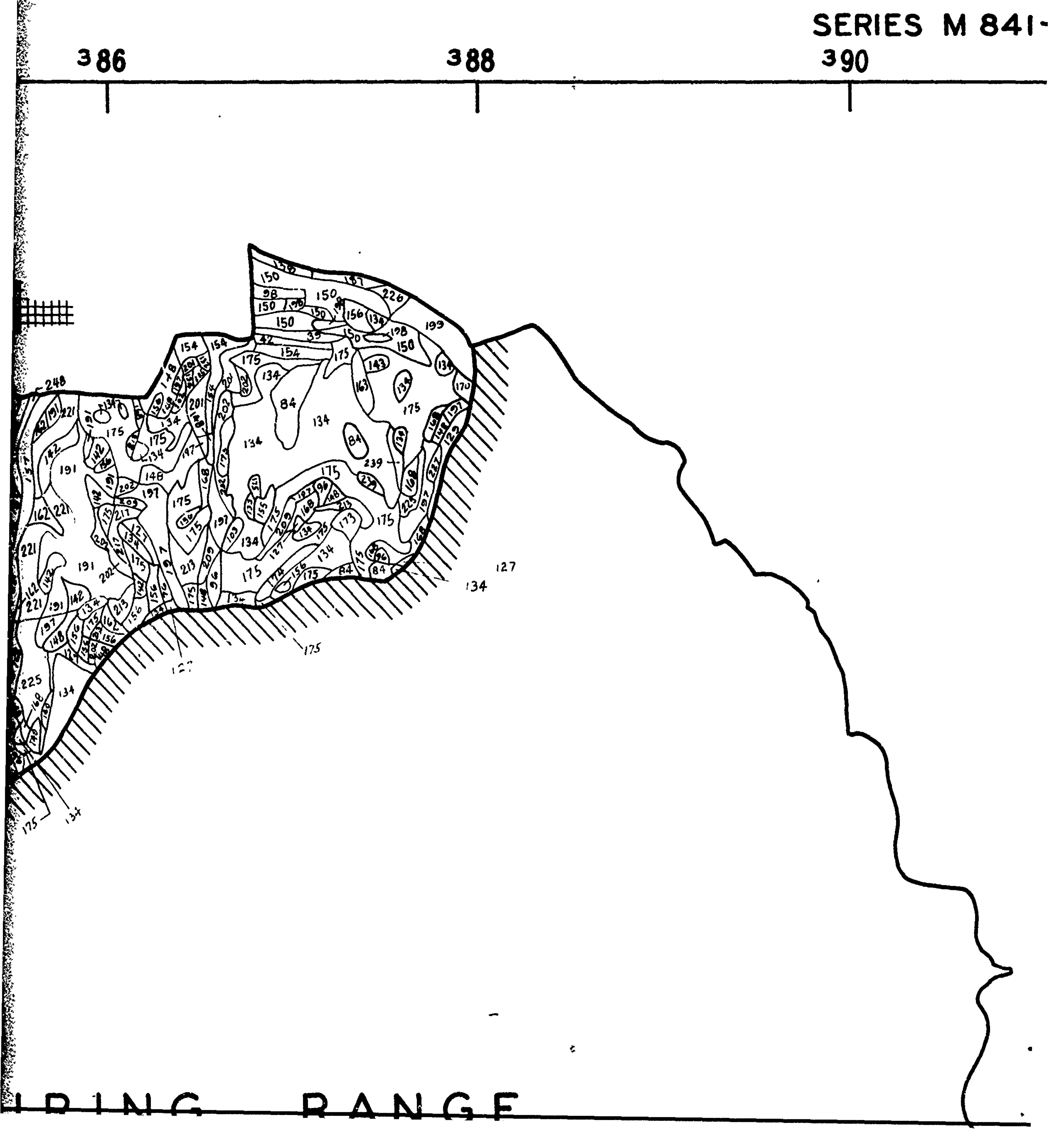
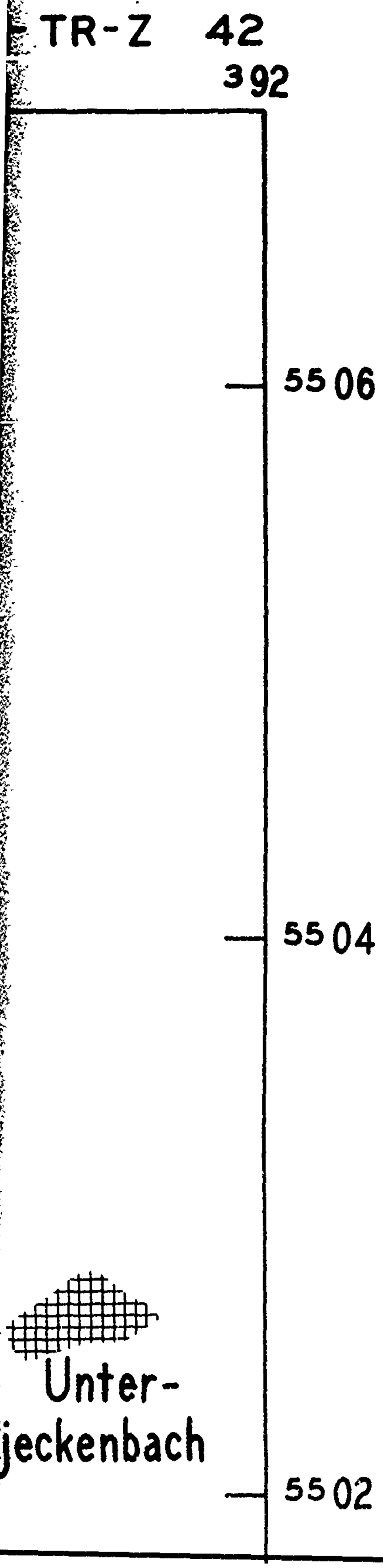


4



Map Unit	SURFACE GEOMETRY					SURFACE COMPOSITION	Spacing of Specified D			
	SL	OS	EA	IA	SH		1.0	2.5	4.0	5.5
1	1	1	1/1	10/10	2/2	7	1	1	1	1
2	1	1	1/1	10/10	2/2	7	2	2	2	2
3	1	1	1/1	10/10	2/2	7	4	4	4	4
4	1	1	1/1	10/10	2/2	7	7	7	7	7
5	1	1	3/2	10/10	1/1	7	1	1	2	7
6	1	1	3/2	10/10	1/1	7	1	1	7	7
7	1	1	3/2	10/10	1/1	7	1	2	2	3
8	1	1	3/2	10/10	1/1	7	2	2	2	2
9	1	1	3/2	10/10	1/1	7	4	4	4	4
10	1	1	3/2	10/10	1/1	7	7	7	7	7
11	1	3	2/2	4/4	2/2	7	1	1	1	1
12	1	3	2/2	4/4	2/2	7	2	2	2	2
13	1	3	2/2	4/4	2/2	7	4	4	4	4
14	1	3	2/2	4/4	2/2	7	8	8	8	8
15	1	3	2/2	4/4	2/2	7	7	7	7	7
16	1	3	4/4	10/10	5/5	7	1	1	2	7
17	1	3	4/4	10/10	5/5	7	2	2	2	2
18	1	3	4/4	10/10	5/5	7	4	4	4	4
19	1	3	4/4	10/10	5/5	7	6	6	6	6
20	1	3	4/4	10/10	5/5	7	7	7	7	7
21	1	4	1/1	1/1	1/1	7	2	3	3	4
22	1	4	1/1	1/1	1/1	7	7	7	7	7
23	2	1	2/2	10/10	1/1	6	1	1	7	7
24	2	1	2/2	10/10	1/1	7	1	1	1	2
25	2	1	2/2	10/10	1/1	7	1	1	2	7
26	2	1	2/2	10/10	1/1	7	1	2	2	3
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28	2	1	2/2	10/10	1/1	7	2	2	2	2
29	2	1	2/2	10/10	1/1	7	2	2	3	4
30	2	1	2/2	10/10	1/1	7	2	2	4	7
31	2	1	2/2	10/10	1/1	7	2	3	3	4
32	2	1	2/2	10/10	1/1	7	4	4	4	4
33	2	1	2/2	10/10	1/1	7	4	4	4	4
34	2	1	2/2	10/10	1/1	7	4	4	4	4
35	2	1	2/2	10/10	1/1	7	4	4	4	4
36	2	1	2/2	10/10	1/1	7	5	5	5	5
37	2	1	2/2	10/10	1/1	7	6	6	6	6
38	2	1	2/2	10/10	1/1	7	7	7	7	7
39	2	1	2/2	10/10	3/3	6	7	7	7	7
40	2	1	2/2	10/10	3/3	7	1	1	1	1
41	2	1	2/2	10/10	3/3	7	4	4	4	[illegible]

5

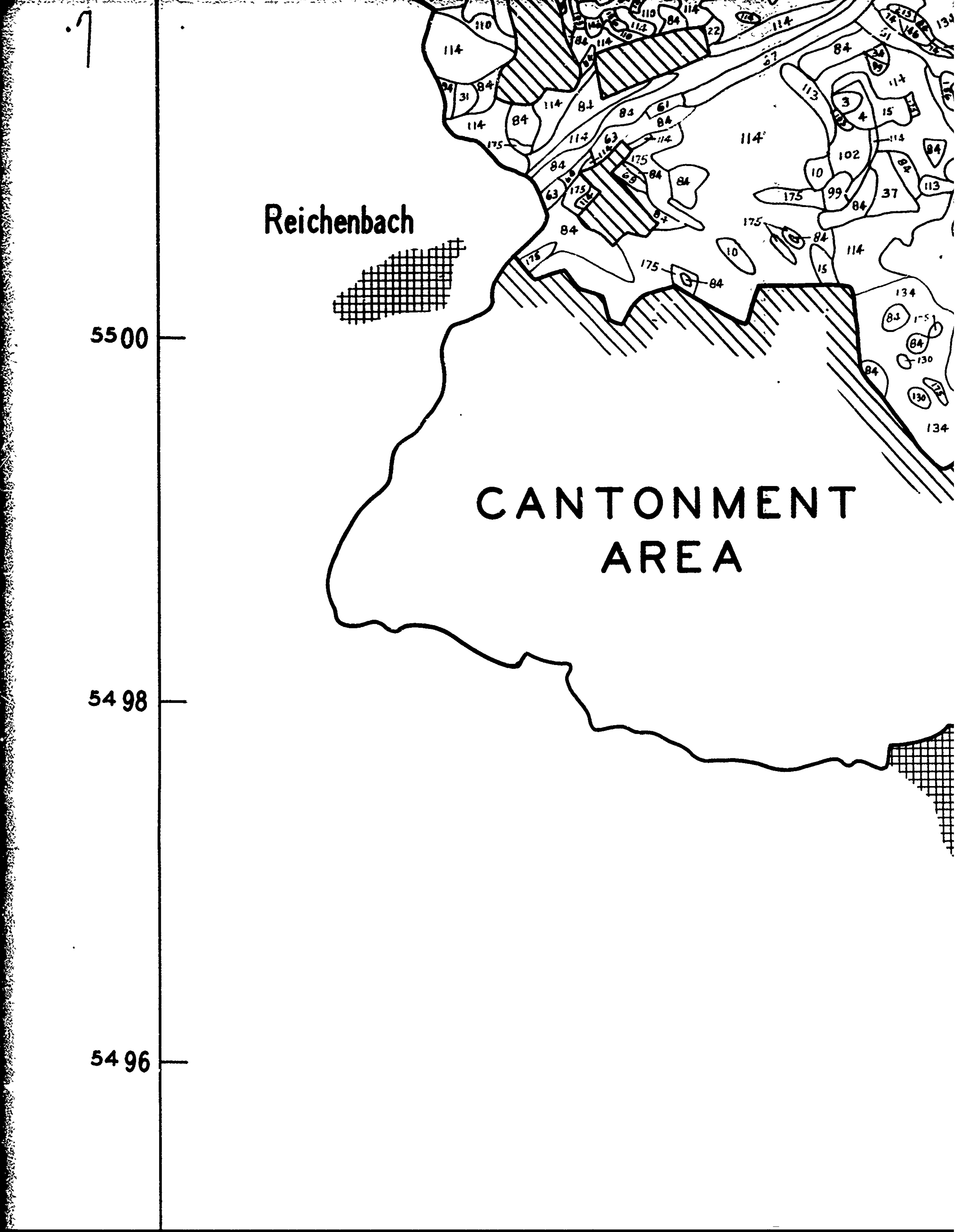
LEGEND

VEGETATION			
Stems > the Specified Diameter, in.			
7.0	8.5	10.0	Visibility
2	2	3	7
3	5	7	7
4	5	5	7
7	7	7	7
7	7	7	4
7	7	7	7
5	7	7	7
3	5	7	7
4	4	4	7
7	7	7	7
2	2	3	7
2	3	5	7
4	5	5	7
8	7	7	7
7	7	7	7
7	7	7	4
3	4	7	7
4	5	5	7
6	6	6	7
7	7	7	7
4	5	5	7
7	7	7	7
7	7	7	7
6	7	7	2
7	7	7	4
5	7	7	7
2	3	5	7
3	5	7	7
7	7	7	7
7	7	7	7
4	5	5	7
4	4	4	7
4	4	5	7
4	5	5	7
4	7	7	7
5	5	5	7
6	6	6	7
7	7	7	7
7	7	7	7
2	2	3	7

Map Unit	SURFACE GEOMETRY					SURFACE COMPOSITION	VEGETATION					
							Spacing of Stems > the Specified Diameter, in.					
	SL	OS	EA	IA	SH		1.0	2.5	4.0	5.5	7.0	8.5
74	2	3	2/2	4/4	2/2	7	2	3	3	4	4	5
75	2	3	2/2	4/4	2/2	7	2	3	4	4	5	7
76	2	3	2/2	4/4	2/2	7	3	3	3	3	3	4
77	2	3	2/2	4/4	2/2	7	4	4	4	4	4	4
78	2	3	2/2	4/4	2/2	7	4	4	4	4	4	4
79	2	3	2/2	4/4	2/2	7	4	4	4	4	4	5
80	2	3	2/2	4/4	2/2	7	4	4	4	4	4	7
81	2	3	2/2	4/4	2/2	7	5	5	5	5	5	5
82	2	3	2/2	4/4	2/2	7	6	6	6	6	6	6
83	2	3	2/2	4/4	2/2	7	6	6	6	6	6	6
84	2	3	2/2	4/4	2/2	7	7	7	7	7	7	7
85	3	1	2/2	10/10	1/1	7	1	1	1	1	2	2
86	3	1	2/2	10/10	1/1	7	1	1	1	2	6	7
87	3	1	2/2	10/10	1/1	7	1	1	1	4	5	5
88	3	1	2/2	10/10	1/1	7	1	1	1	7	7	7
89	3	1	2/2	10/10	1/1	7	1	1	2	7	7	7
90	3	1	2/2	10/10	1/1	7	1	2	2	3	5	7
91	3	1	2/2	10/10	1/1	7	2	2	2	2	2	3
92	3	1	2/2	10/10	1/1	7	2	2	2	2	3	5
93	3	1	2/2	10/10	1/1	7	2	2	3	4	7	7
94	3	1	2/2	10/10	1/1	7	2	3	3	4	4	5
95	3	1	2/2	10/10	1/1	7	2	3	4	4	5	7
96	3	1	2/2	10/10	1/1	7	3	3	3	3	3	4
97	3	1	2/2	10/10	1/1	7	4	4	4	4	4	4
98	3	1	2/2	10/10	1/1	7	4	4	4	4	4	4
99	3	1	2/2	10/10	1/1	7	4	4	4	4	4	5
100	3	1	2/2	10/10	1/1	7	4	4	4	4	4	7
101	3	1	2/2	10/10	1/1	7	5	5	5	5	5	5
102	3	1	2/2	10/10	1/1	7	6	6	6	6	6	6
103	3	1	2/2	10/10	1/1	7	7	7	7	7	7	7
104	3	2	2/2	5/5	1/1	2	7	7	7	7	7	7
105	3	2	2/2	5/5	1/1	4	7	7	7	7	7	7
106	3	2	2/2	5/5	1/1	5	7	7	7	7	7	7
107	3	2	2/2	5/5	1/1	7	1	1	1	4	5	5
108	3	2	2/2	5/5	1/1	7	1	2	2	3	5	7
109	3	2	2/2	5/5	1/1	7	2	2	3	4	7	7
110	3	2	2/2	5/5	1/1	7	2	3	3	4	4	5
111	3	2	2/2	5/5	1/1	7	2	3	4	4	5	7
112	3	2	2/2	5/5	1/1	7	4	4	4	4	4	7
113	3	2	2/2	5/5	1/1	7	6	6	6	6	6	6

6

Visibility	Map Unit	SURFACE GEOMETRY SL	OS	EA	IA	SH	SURFACE COMPOSITION	VEGETATION: Spacing of Stems > the Specified Diameter, in. 1.0	2.5	4.0	5.5	7.0	8.5	10.0	Visibility
7	147	4	1	2/2	10/10	2/2	7	2	2	4	4	5	7	7	7
7	148	4	1	2/2	10/10	2/2	7	3	3	3	3	3	4	5	7
7	149	4	1	2/2	10/10	2/2	7	4	4	4	4	4	4	4	7
7	150	4	1	2/2	10/10	2/2	7	4	4	4	4	4	4	5	7
7	151	4	1	2/2	10/10	2/2	7	4	4	4	4	4	5	5	7
7	152	4	1	2/2	10/10	2/2	7	4	4	4	4	4	7	7	7
7	153	4	1	2/2	10/10	2/2	7	5	5	5	5	5	5	5	7
7	154	4	1	2/2	10/10	2/2	7	6	6	6	6	6	6	6	7
7	155	4	1	2/2	10/10	2/2	7	6	6	6	6	6	6	7	7
7	156	4	1	2/2	10/10	2/2	7	7	7	7	7	7	7	7	7
7	157	4	3	2/2	5/5	1/1	6	7	7	7	7	7	7	7	7
7	158	4	3	2/2	5/5	1/1	7	1	1	1	2	5	7	7	2
2	159	4	3	2/2	5/5	1/1	7	1	1	1	4	5	5	5	7
7	160	4	3	2/2	5/5	1/1	7	1	1	2	7	7	7	7	4
1	161	4	3	2/2	5/5	1/1	7	1	1	7	[illegible]	7	7	7	7
4	162	4	3	2/2	5/5	1/1	7	1	2	2	3	5	7	7	7
7	163	4	3	2/2	5/5	1/1	7	2	2	2	2	2	3	5	7
7	164	4	3	2/2	5/5	1/1	7	2	2	2	2	3	5	7	7
7	165	4	3	2/2	5/5	1/1	7	2	2	3	4	7	7	7	7
7	166	4	3	2/2	5/5	1/1	7	2	3	3	4	4	5	5	7
7	167	4	3	2/2	5/5	1/1	7	2	3	4	4	5	7	7	7
7	168	4	3	2/2	5/5	1/1	7	3	3	3	3	3	4	5	7
7	169	4	3	2/2	5/5	1/1	7	4	4	4	4	4	4	5	7
7	170	4	3	2/2	5/5	1/1	7	4	4	4	4	4	5	5	7
7	171	4	3	2/2	5/5	1/1	7	4	4	4	4	4	7	7	7
7	172	4	3	2/2	5/5	1/1	7	5	5	5	5	5	5	5	7
7	173	4	3	2/2	5/5	1/1	7	6	6	6	6	6	6	6	7
7	174	4	3	2/2	5/5	1/1	7	6	6	6	6	6	6	7	7
7	175	4	3	2/2	5/5	1/1	7	7	7	7	7	7	7	7	7
7	176	4	4	1/3	10/7	7/6	2	7	7	7	7	7	7	7	7
7	177	4	4	1/3	10/7	7/6	7	1	1	1	7	7	7	7	1
7	178	4	4	1/3	10/7	7/6	7	1	1	2	7	7	7	7	4
7	179	4	4	1/3	10/7	7/6	7	2	2	2	2	3	5	7	7
7	180	4	4	1/3	10/7	7/6	7	2	3	4	4	5	7	7	7
7	181	4	4	1/3	10/7	7/6	7	5	5	5	5	5	5	5	7
7	182	4	4	1/3	10/7	7/6	7	7	7	7	7	7	7	7	7
7	183	4	4	2/3	7/8	4/7	7	1	1	1	1	2	2	3	7
7	184	4	4	2/3	7/8	4/7	7	2	2	3	4	7	7	7	7
7	185	4	4	2/3	7/8	4/7	7	7	7	7	7	7	7	7	7
7	186	5	1	2/2	10/10	2/2	7	1	1	1	1	2	2	3	7
	187	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]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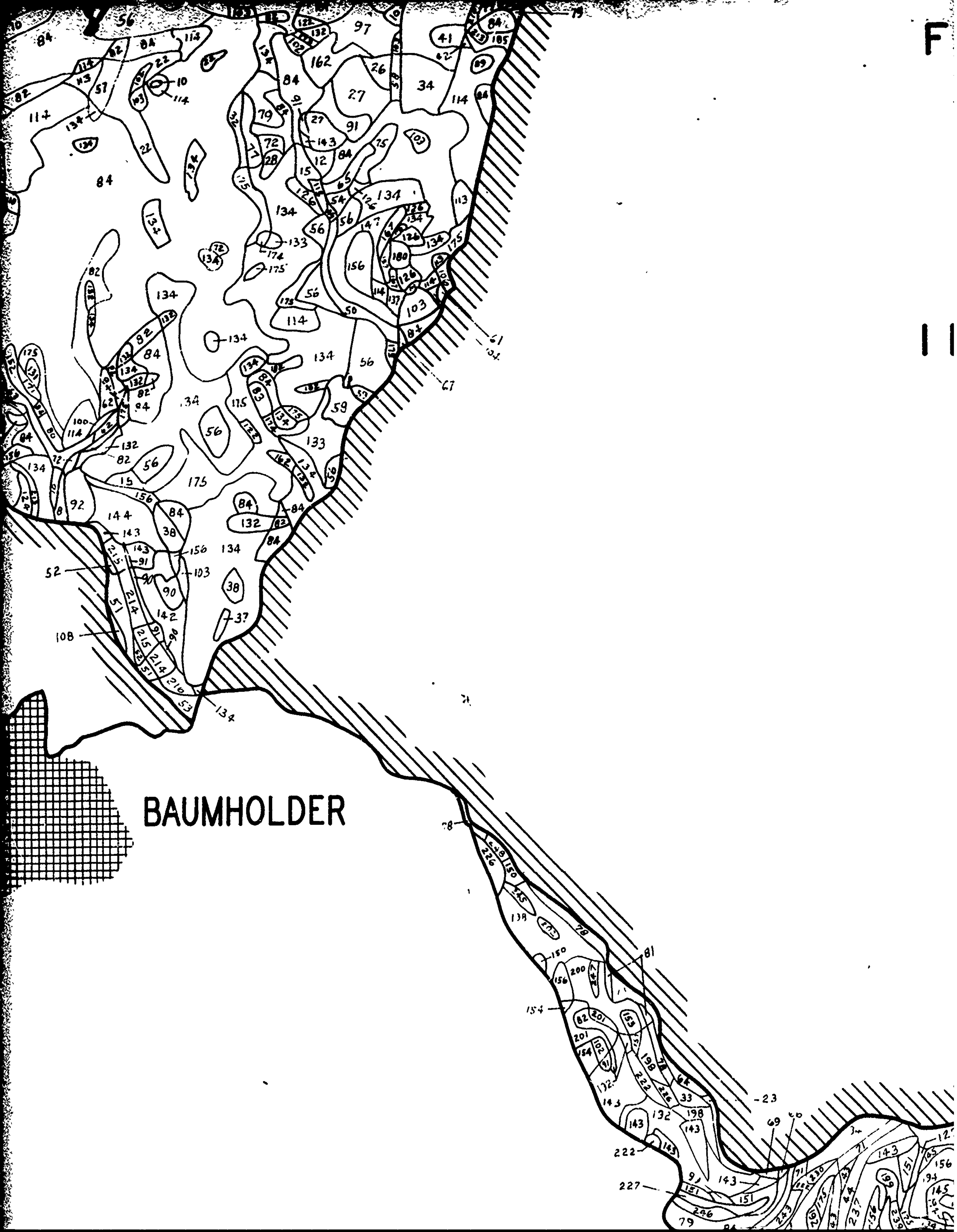

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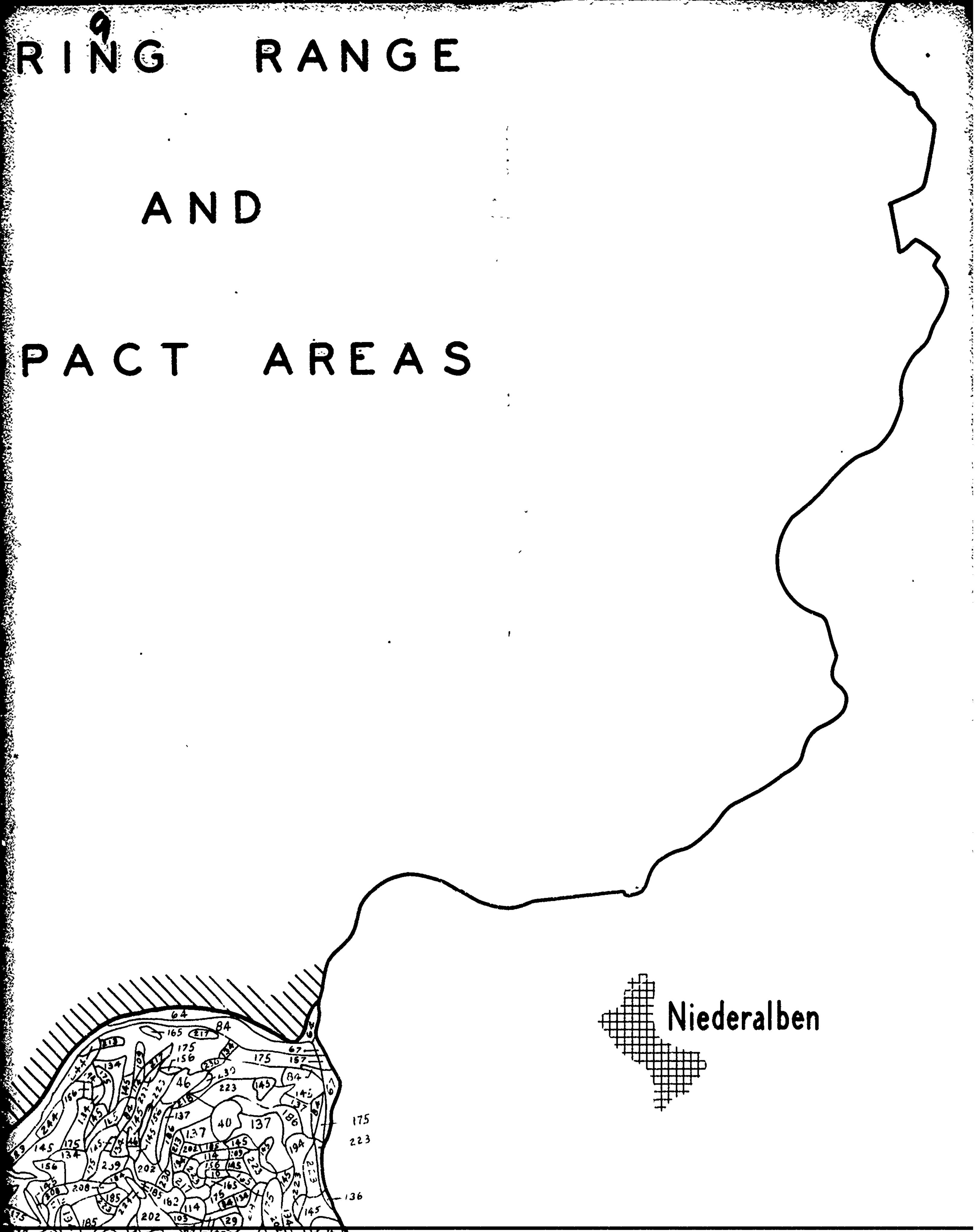
AND

PACT AREAS



10

5502

39	2	1	2/2	10/10	3/3	[illegible]	7	7	7	7	7	7
40	2	1	2/2	10/10	3/3	7	1	1	1	1	2	2
41	2	1	2/2	10/10	3/3	7	4	4	4	4	4	5
42	2	1	2/2	10/10	3/3	7	6	6	6	6	6	6
43	2	1	3/3	10/10	5/6	7	2	2	2	2	2	3
44	2	1	3/3	10/10	5/6	7	4	4	4	4	4	5
45	2	1	3/3	10/10	5/6	7	5	5	5	5	5	5
46	2	1	3/3	10/10	5/6	7	7	7	7	7	7	7
47	2	1	5/3	10/4	8/8	7	5	5	5	5	5	5
48	2	1	5/3	10/4	8/8	7	7	7	7	7	7	7
49	2	1	7/4	10/10	1/1	6	2	3	4	4	5	7
50	2	1	7/4	10/10	1/1	6	7	7	7	7	7	7
51	2	1	7/4	10/10	1/1	7	1	2	2	3	5	7
52	2	1	7/4	10/10	1/1	7	2	2	2	2	2	3
53	2	1	7/4	10/10	1/1	7	2	2	2	2	3	5
54	2	1	7/4	10/10	1/1	7	2	3	4	4	5	7
55	2	1	7/4	10/10	1/1	7	6	6	6	6	6	6
56	2	1	7/4	10/10	1/1	7	7	7	7	7	7	7
57	2	2	3/3	6/6	8/8	7	6	6	6	6	6	6
58	2	2	3/3	6/6	8/8	7	6	6	6	6	6	6
59	2	2	3/3	6/6	8/8	7	7	7	7	7	7	7
60	2	3	2/2	4/4	2/2	2	6	6	6	6	6	6
61	2	3	2/2	4/4	2/2	2	7	7	7	7	7	7
62	2	3	2/2	4/4	2/2	5	6	6	6	6	6	6
63	2	3	2/2	4/4	2/2	5	7	7	7	7	7	7
64	2	3	2/2	4/4	2/2	6	2	2	3	4	7	7
65	2	3	2/2	4/4	2/2	6	2	3	4	4	5	7
66	2	3	2/2	4/4	2/2	6	4	4	4	4	4	5
67	2	3	2/2	4/4	2/2	6	7	7	7	7	7	7
68	2	3	2/2	4/4	2/2	7	1	1	1	2	6	7
69	2	3	2/2	4/4	2/2	7	1	1	7	7	7	7
70	2	3	2/2	4/4	2/2	7	1	2	2	3	5	7
71	2	3	2/2	4/4	2/2	7	2	2	2	2	2	3
72	2	3	2/2	4/4	2/2	7	2	2	2	2	3	5
73	2	3	2/2	4/4	2/2	7	2	2	4	7	7	7

5500

5498

Map Unit	SURFACE GEOMETRY					SURFACE COMPOSITION	VEGETATI					
							Spacing of Stems > Specified Diameter,					
	SL	OS	EA	IA	SH		1.0	2.5	4.0	5.5	7.0	8
221	6	1	2/2	10/10	3/3	7	1	2	2	3	5	
222	6	1	2/2	10/10	3/3	7	2	2	2	2	2	
223	6	1	2/2	10/10	3/3	7	2	2	3	4	7	
224	6	1	2/2	10/10	3/3	7	2	3	3	4	4	
225	6	1	2/2	10/10	3/3	7	3	3	3	3	3	
226	6	1	2/2	10/10	3/3	7	4	4	4	4	4	
227	6	1	2/2	10/10	3/3	7	4	4	4	4	4	
228	6	1	2/2	10/10	3/3	7	4	4	4	4	4	
229	6	1	2/2	10/10	3/3	7	5	5	5	5	5	
230	6	1	2/2	10/10	3/3	7	7	7	7	7	7	
231	6	2	3/3	8/8	3/3	7	1	1	1	2	6	
232	6	2	3/3	8/8	3/3	7	1	1	1	7	7	
233	6	2	3/3	8/8	3/3	7	1	1	2	7	7	
234	6	2	3/3	8/8	3/3	7	2	2	2	2	2	
235	6	2	3/3	8/8	3/3	7	2	2	2	2	3	
236	6	2	3/3	8/8	3/3	7	2	2	3	4	7	
237	6	2	3/3	8/8	3/3	7	4	4	4	4	4	
238	6	2	3/3	8/8	3/3	7	55	5	5	5	5	
239	6	2	3/3	8/8	3/3	7	7	7	7	7	7	
240	6	4	9/9	10/10	8/8	7	1	1	2	7	7	
241	6	4	9/9	10/10	8/8	7	7	7	7	7	7	

5496

	111	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	3	4	4	5	7	7	7
7	112	3	2	2/2	5/5	1/1	7	4	4	4	4	4	7	7	7
7	113	3	2	2/2	5/5	1/1	7	6	6	6	6	6	6	6	7
7	114	3	2	2/2	5/5	1/1	7	7	7	7	7	7	7	7	7
7	115	3	4	2/3	3/4	1/1	6	2	3	4	4	5	7	7	7
7	116	3	4	2/3	3/4	1/1	6	7	7	7	7	7	7	7	7
7	117	3	4	2/3	3/4	1/1	7	1	1	1	1	2	2	3	7
7	118	3	4	2/3	3/4	1/1	7	1	1	1	2	6	7	7	2
7	119	3	4	2/3	3/4	1/1	7	1	1	1	4	5	5	5	7
7	120	3	4	2/3	3/4	1/1	7	1	1	2	7	7	7	7	7
7	121	3	4	2/3	3/4	1/1	7	1	1	7	7	7	7	7	7
7	122	3	4	2/3	3/4	1/1	7	1	2	2	3	5	7	7	7
7	123	3	4	2/3	3/4	1/1	7	2	2	2	2	2	3	5	7
7	124	3	4	2/3	3/4	1/1	7	2	2	2	2	2	5	7	7
7	125	3	4	2/3	3/4	1/1	7	2	2	3	4	7	7	7	7
7	126	3	4	2/3	3/4	1/1	7	2	3	4	4	5	7	7	7
7	127	3	4	2/3	3/4	1/1	7	3	3	3	3	3	4	5	7
7	128	3	4	2/3	3/4	1/1	7	4	4	4	4	4	4	5	7
7	129	3	4	2/3	3/4	1/1	7	4	4	4	4	4	5	5	7
7	130	3	4	2/3	3/4	1/1	7	4	4	4	4	4	7	7	7
7	131	3	4	2/3	3/4	1/1	7	5	5	5	5	5	5	5	7
7	132	3	4	2/3	3/4	1/1	7	6	6	6	6	6	6	6	7
7	133	3	4	2/3	3/4	1/1	7	6	6	6	6	6	6	7	7
7	134	3	4	2/3	3/4	1/1	7	7	7	7	7	7	7	7	7
7	135	4	1	2/2	10/10	2/2	2	6	6	6	6	6	6	6	7
7	136	4	1	2/2	10/10	2/2	6	2	2	3	4	7	7	7	7
7	137	4	1	2/2	10/10	2/2	7	1	1	1	1	2	2	3	7
7	138	4	1	2/2	10/10	2/2	7	1	1	1	2	6	7	7	2
7	139	4	1	2/2	10/10	2/2	7	1	1	1	4	5	5	5	7
7	140	4	1	2/2	10/10	2/2	7	1	1	1	7	7	7	7	1
2	141	4	1	2/2	10/10	2/2	7	1	1	2	7	7	7	7	4
7	142	4	1	2/2	10/10	2/2	7	1	2	2	3	5	7	7	7
7	143	4	1	2/2	10/10	2/2	7	2	2	2	2	2	3	5	7
7	144	4	1	2/2	10/10	2/2	7	2	2	2	2	2	3	5	7
7	145	4	1	2/2	10/10	2/2	7	2	2	3	4	7	7	7	7
7	146	4	1	2/2	10/10	2/2	7	2	3	3	4	4	5	5	7

0.0	Visibility
7	7
5	7
7	7
5	7
5	7
5	7
5	7
7	7
5	7
7	7
7	2
7	1
7	4
5	7
7	7
7	7
5	7
6	7
7	7

*Each map unit represents an array of symbols [i.e. 1,1,(1/1 10/10),2/2] indicati mapping classes of slope SL (see diagram below) obstacle spacing OS, approach ang EA and IA, and step height SH. Fractional designations indicate that dual classe were mapped. The numerator of the fraction indicates class range that will be en countered while traversing an area in an easterly direction (i.e. azimuth from >0 180 deg) and the denominator refers to a westerly direction (i.e. azimuth from > to 360 deg) assuming that the vehicle intersects the obstacle at a right angle.

*Mapping class ranges of each surface geometry factor are:

Slope (SL)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31

Spacing (OS)	
Map Class	ft
1	0-50
2	>50-150
3	>150-225
4	>225

Approach Angle (EA-IA)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45

Step Height (SH)	
Map Class	in
1	<8
2	8-10
3	>10-1[illegible]
4	>12-1[illegible]
5	>14-1[illegible]
6	>16-2[illegible]
7	>20-3[illegible]
8	>30

7	184	4	4	2/3	7/8	4/7	7	2	2	3	4	7	7	7	7
7	185	4	4	2/3	7/8	4/7	7	7	7	7	7	7	7	7	7
7	186	5	1	2/2	10/10	2/2	7	1	1	1	1	2	2	3	7
7	187	5	1	2/2	10/10	2/2	7	1	1	1	2	6	7	7	2
7	188	5	1	2/2	10/10	2/2	7	1	1	1	4	5	5	5	7
7	189	5	1	2/2	10/10	2/2	7	1	1	2	7	7	7	7	4
7	190	5	1	2/2	10/10	2/2	7	1	1	7	7	7	7	7	7
2	191	5	1	2/2	10/10	2/2	7	1	2	2	3	5	7	7	7
7	192	5	1	2/2	10/10	2/2	7	2	2	2	2	2	3	5	7
7	193	5	1	2/2	10/10	2/2	7	2	2	2	2	3	5	7	7
7	194	5	1	2/2	10/10	2/2	7	2	2	3	4	7	7	7	7
7	195	5	1	2/2	10/10	2/2	7	2	3	3	4	4	5	5	7
7	196	5	1	2/2	10/10	2/2	7	2	3	4	4	5	7	7	7
7	197	5	1	2/2	10/10	2/2	7	3	3	3	3	3	4	5	7
7	198	5	1	2/2	10/10	2/2	7	4	4	4	4	4	4	5	7
7	199	5	1	2/2	10/10	2/2	7	4	4	4	4	4	5	5	7
7	200	5	1	2/2	10/10	2/2	7	5	5	5	5	5	5	5	7
7	201	5	1	2/2	10/10	2/2	7	6	6	6	6	6	6	6	7
7	202	5	1	2/2	10/10	2/2	7	7	7	7	7	7	7	7	7
7	203	5	3	2/2	5/5	3/3	7	1	1	1	1	2	2	3	7
7	204	5	3	2/2	5/5	3/3	7	1	1	1	4	5	5	5	7
7	205	5	3	2/2	5/5	3/3	7	1	1	1	7	7	7	7	1
7	206	5	3	2/2	5/5	3/3	7	1	1	2	7	7	7	7	4
7	207	5	3	2/2	5/5	3/3	7	2	2	2	2	3	5	7	7
7	208	5	3	2/2	5/5	3/3	7	2	2	3	4	7	7	7	7
7	209	5	3	2/2	5/5	3/3	7	3	3	3	3	3	4	5	7
7	210	5	3	2/2	5/5	3/3	7	4	4	4	4	4	5	5	7
2	211	5	3	2/2	5/5	3/3	7	5	5	5	5	5	5	5	7
7	212	5	3	2/2	5/5	3/3	7	6	6	6	6	6	6	6	7
1	213	5	3	2/2	5/5	3/3	7	7	7	7	7	7	7	7	7
4	214	5	4	7/7	10/10	8/8	7	1	2	2	3	5	7	7	7
7	215	5	4	7/7	10/10	8/8	7	2	2	2	2	2	3	5	7
7	216	5	4	7/7	10/10	8/8	7	2	2	2	2	3	5	7	7
7	217	5	4	7/7	10/10	8/8	7	7	7	7	7	7	7	7	7
7	218	6	1	2/2	10/10	3/3	7	1	1	1	1	2	2	3	7
7	219	6	1	2/2	10/10	3/3	7	1	1	1	2	6	7	7	2
	220	6	1	2/2	10/10	3/3	7	1	1	1	4	5	5	5	7

cating
angle
asses
en-
m'0 to
>180
e.

(SH)
n
-10
0-12
2-14
4-16
6-20
0-30
0

**Mapping class ranges for each Surface Composition unit are:

Map Class	6-12 in RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

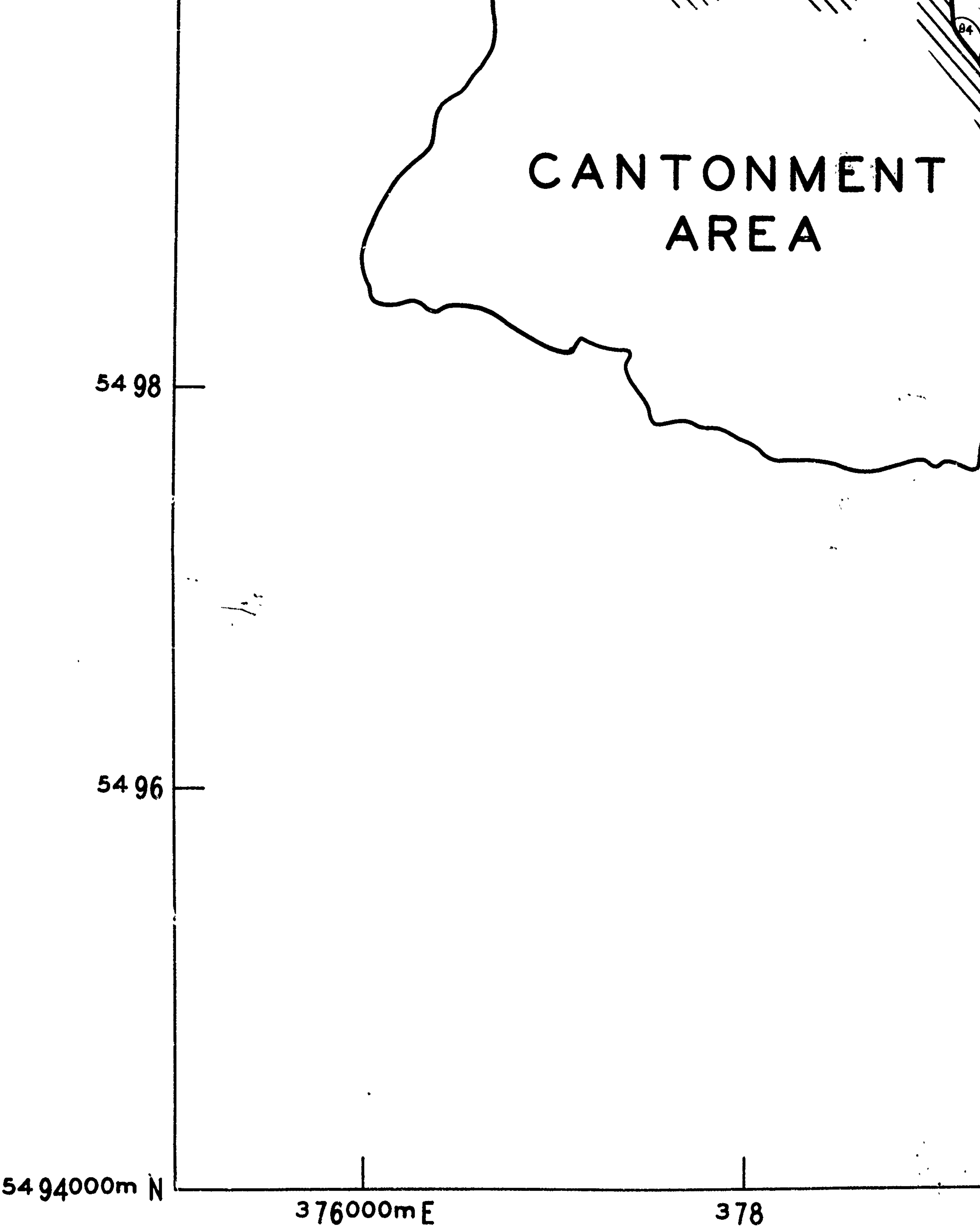
Map Class	0-6 in CI
1S	0-20
2S	>20-40
3S	>40-75
4S	>75-125
5S	>125-175
6S	>175-250
7S	>250

Map Class	6-12 in CI
1M	0-15
2M	>15-30
3M	>30-45
4M	>45-60
5M	>60-80
6M	>80

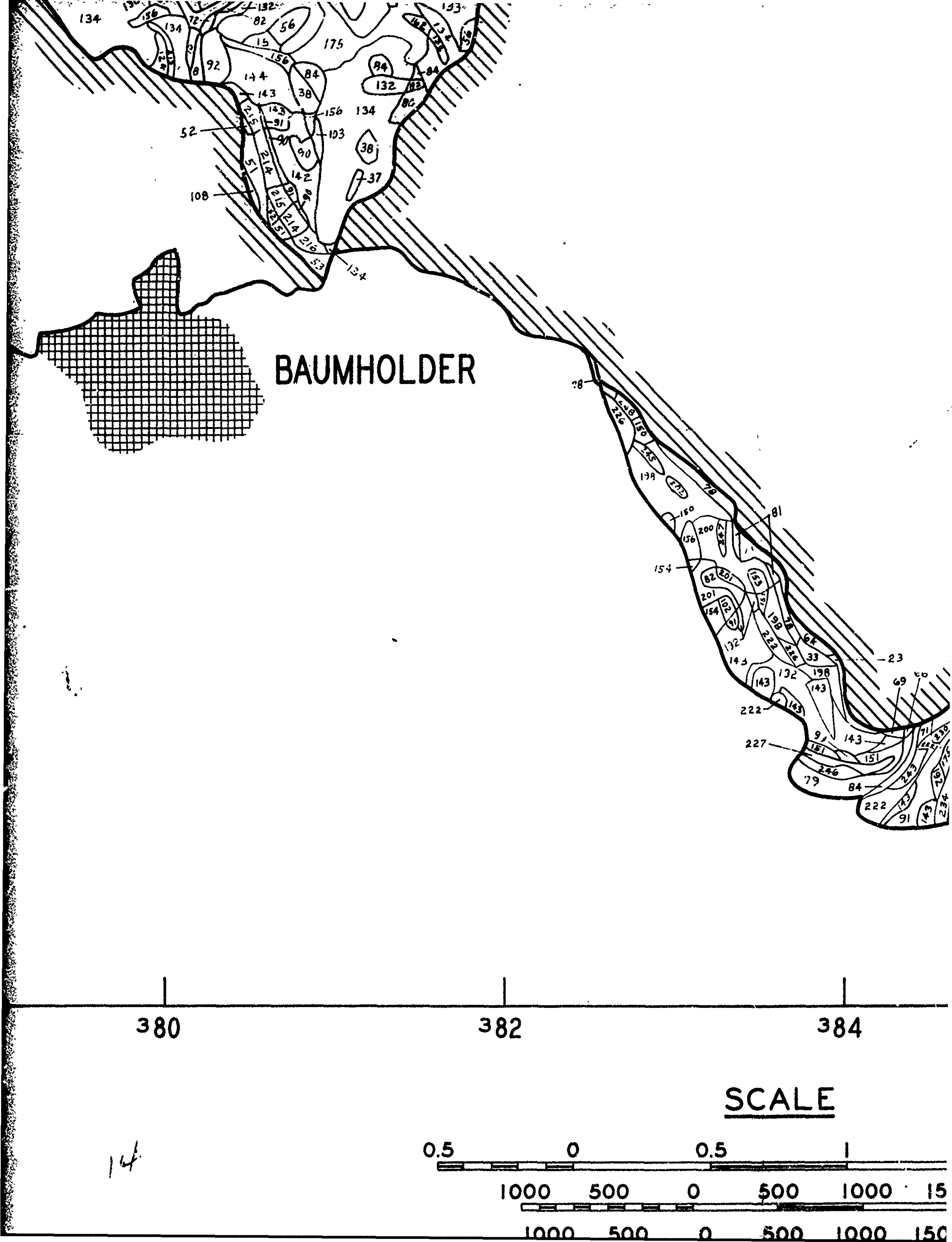
***Mapping class ranges for each spacing class and visibility class are:

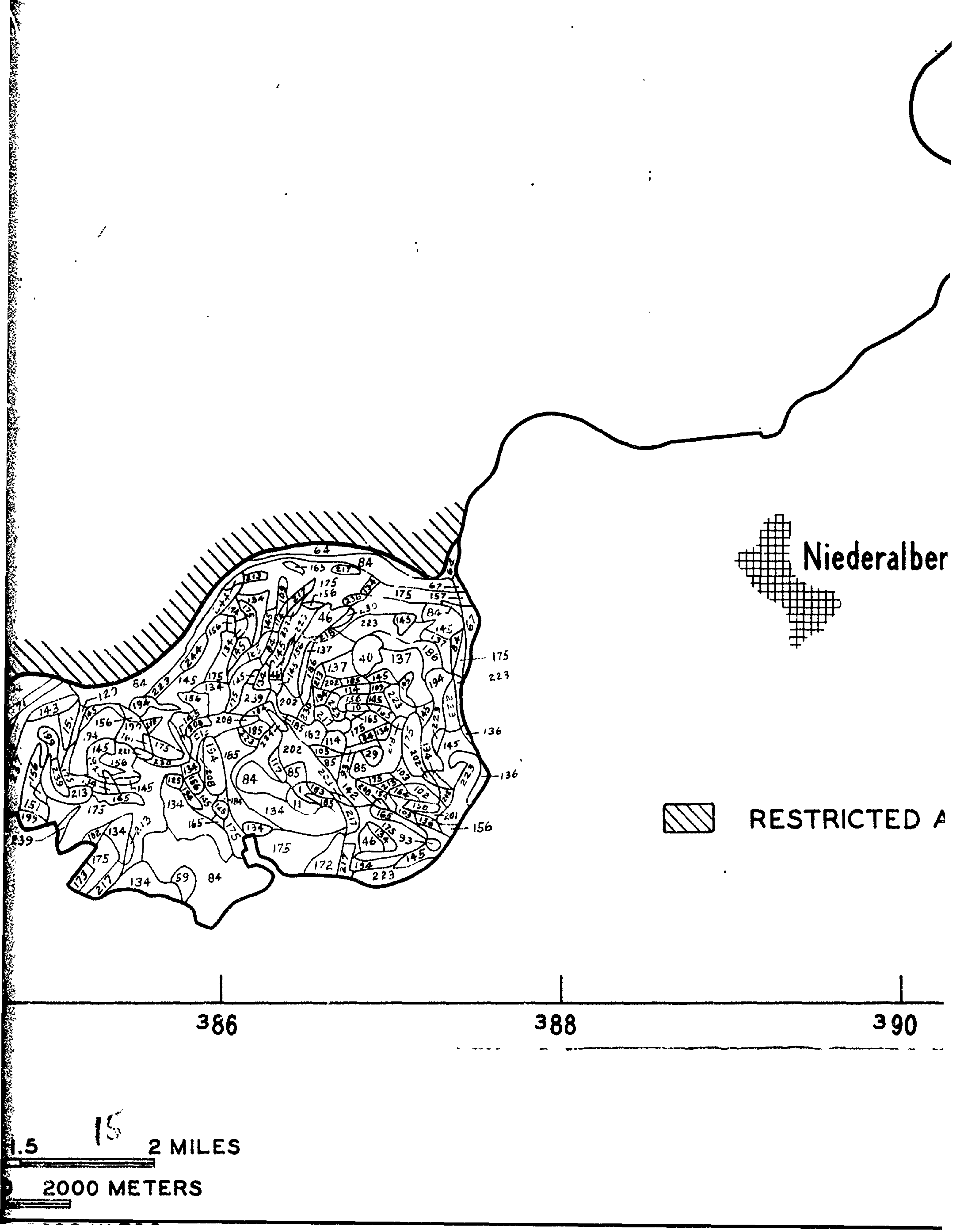
Stem Spacing	
Map Class	ft

Visibility	
Map Class	ft

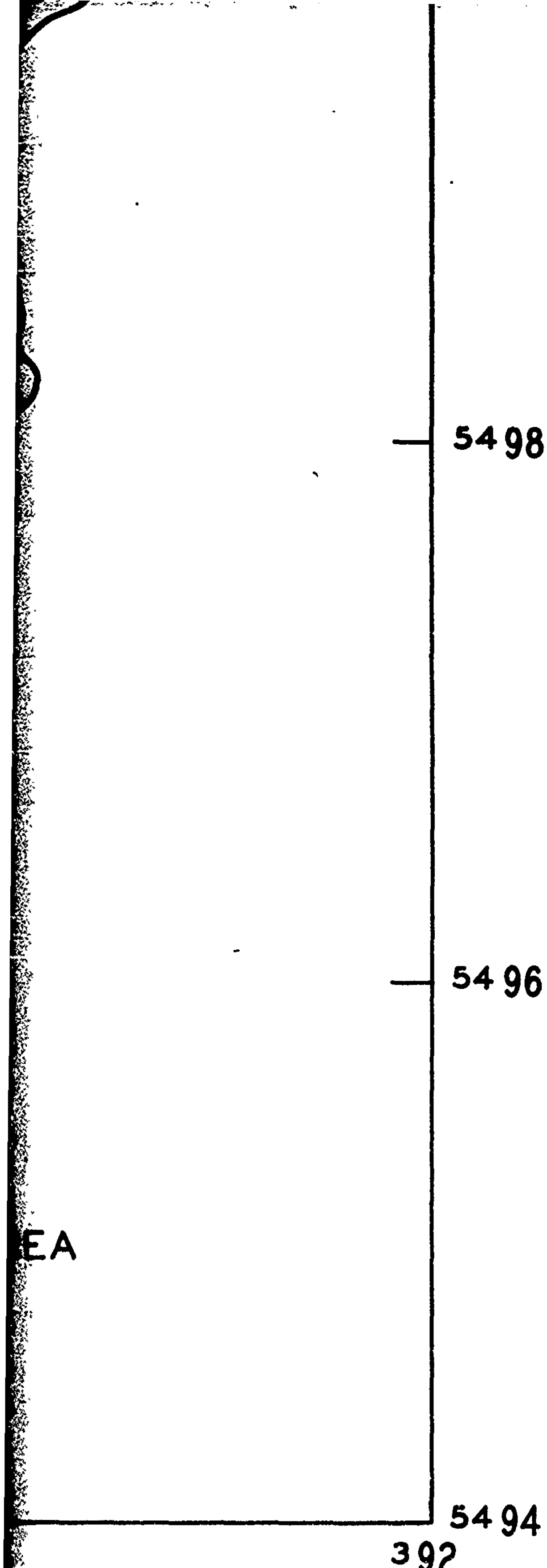


13


BAUMHOLDER
380
382
384
SCALE
0.5
0
0.5
1
1000
500
0
500
1000
14



15



16

62	2	3	2/2	4/4	2/2	5	6	6
63	2	3	2/2	4/4	2/2	5	7	7
64	2	3	2/2	4/4	2/2	6	2	2
65	2	3	2/2	4/4	2/2	6	2	3
66	2	3	2/2	4/4	2/2	6	4	4
67	2	3	2/2	4/4	2/2	6	7	7
68	2	3	2/2	4/4	2/2	7	1	1
69	2	3	2/2	4/4	2/2	7	1	1
70	2	3	2/2	4/4	2/2	7	1	2
71	2	3	2/2	4/4	2/2	7	2	2
72	2	3	2/2	4/4	2/2	7	2	2
73	2	3	2/2	4/4	2/2	7	2	2

Map Unit	SURFACE GEOMETRY					SURFACE COMPOSITION		
	SL	OS	EA	IA	SH		1.0	2.
221	6	1	2/2	10/10	3/3	7	1	[illegible]
222	6	1	2/2	10/10	3/3	7	2	[illegible]
223	6	1	2/2	10/10	3/3	7	2	[illegible]
224	6	1	2/2	10/10	3/3	7	2	[illegible]
225	6	1	2/2	10/10	3/3	7	3	[illegible]
226	6	1	2/2	10/10	3/3	7	4	[illegible]
227	6	1	2/2	10/10	3/3	7	4	[illegible]
228	6	1	2/2	10/10	3/3	7	4	[illegible]
229	6	1	2/2	10/10	3/3	7	5	[illegible]
230	6	1	2/2	10/10	3/3	7	7	[illegible]
231	6	2	3/3	8/8	3/3	7	1	[illegible]
232	6	2	3/3	8/8	3/3	7	1	[illegible]
233	6	2	3/3	8/8	3/3	7	1	[illegible]
234	6	2	3/3	8/8	3/3	7	2	[illegible]
235	6	2	3/3	8/8	3/3	7	2	[illegible]
236	6	2	3/3	8/8	3/3	7	2	[illegible]
237	6	2	3/3	8/8	3/3	7	4	[illegible]
238	6	2	3/3	8/8	3/3	7	55	[illegible]
239	6	2	3/3	8/8	3/3	7	7	[illegible]
240	6	4	9/9	10/10	8/8	7	1	[illegible]
241	6	4	9/9	10/10	8/8	7	7	[illegible]
242	7	3	2/2	6/6	7/7	7	1	[illegible]
243	7	3	2/2	6/6	7/7	7	2	[illegible]
244	7	3	2/2	6/6	7/7	7	2	[illegible]
245	7	3	2/2	6/6	7/7	7	4	[illegible]
246	7	3	2/2	6/6	7/7	7	4	[illegible]
247	7	3	2/2	6/6	7/7	7	5	[illegible]
248	7	3	2/2	6/6	7/7	7	7	[illegible]

206	5	3	2/2	5/5	3/3	7	1	1	2	7	7	7	7	[illegible]
207	5	3	2/2	5/5	3/3	7	2	2	2	2	3	5	7	7
208	5	3	2/2	5/5	3/3	7	2	2	3	4	7	7	7	7
209	5	3	2/2	5/5	3/3	7	3	3	3	3	3	4	5	7
210	5	3	2/2	5/5	3/3	7	4	4	4	4	4	5	5	7
211	5	3	2/2	5/5	3/3	7	5	5	5	5	5	5	5	7
212	5	3	2/2	5/5	3/3	7	6	6	6	6	6	6	6	7
213	5	3	2/2	5/5	3/3	7	7	7	7	7	7	7	7	7
214	5	4	7/7	10/10	8/8	7	1	2	2	3	5	7	7	7
215	5	4	7/7	10/10	8/8	7	2	2	2	2	2	3	5	7
216	5	4	7/7	10/10	8/8	7	2	2	2	2	3	5	7	7
217	5	4	7/7	10/10	8/8	7	7	7	7	7	7	7	7	7
218	6	1	2/2	10/10	3/3	7	1	1	1	1	2	2	3	7
219	6	1	2/2	10/10	3/3	7	1	1	1	2	6	7	7	2
220	6	1	2/2	10/10	3/3	7	1	1	1	4	5	5	5	7

**Mapping class ranges for each Surface Composition unit are:

Map Class	6-12 in RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

Map Class	0-6 in CI
1S	0-20
2S	>20-40
3S	>40-75
4S	>75-125
5S	>125-175
6S	>175-250
7S	>250

Map Class	6-12 in CI
1M	0-15
2M	>15-30
3M	>30-45
4M	>45-60
5M	>60-80
6M	>80

***Mapping class ranges for each spacing class and visibility class are:

Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

Visibility	
Map Class	ft
1	<15
2	15-21
3	> 21-27
4	> 27-33
5	> 33-39
6	> 39-45
7	> 45

TERRAIN FACTOR COMPLEX MAP
WEST GERMANY

AREAL FACTOR COMPLEXES
BAUMHOLDER

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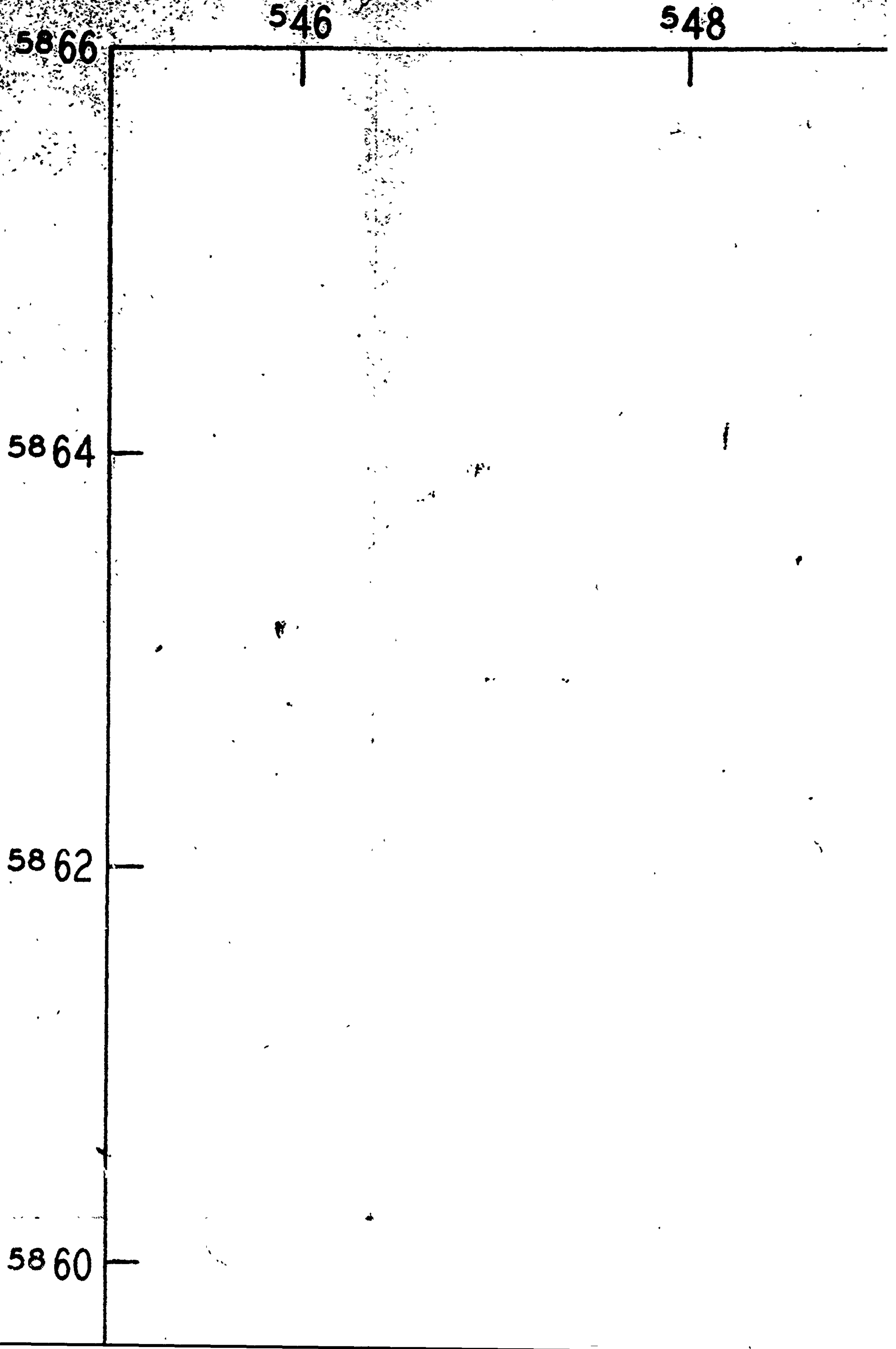
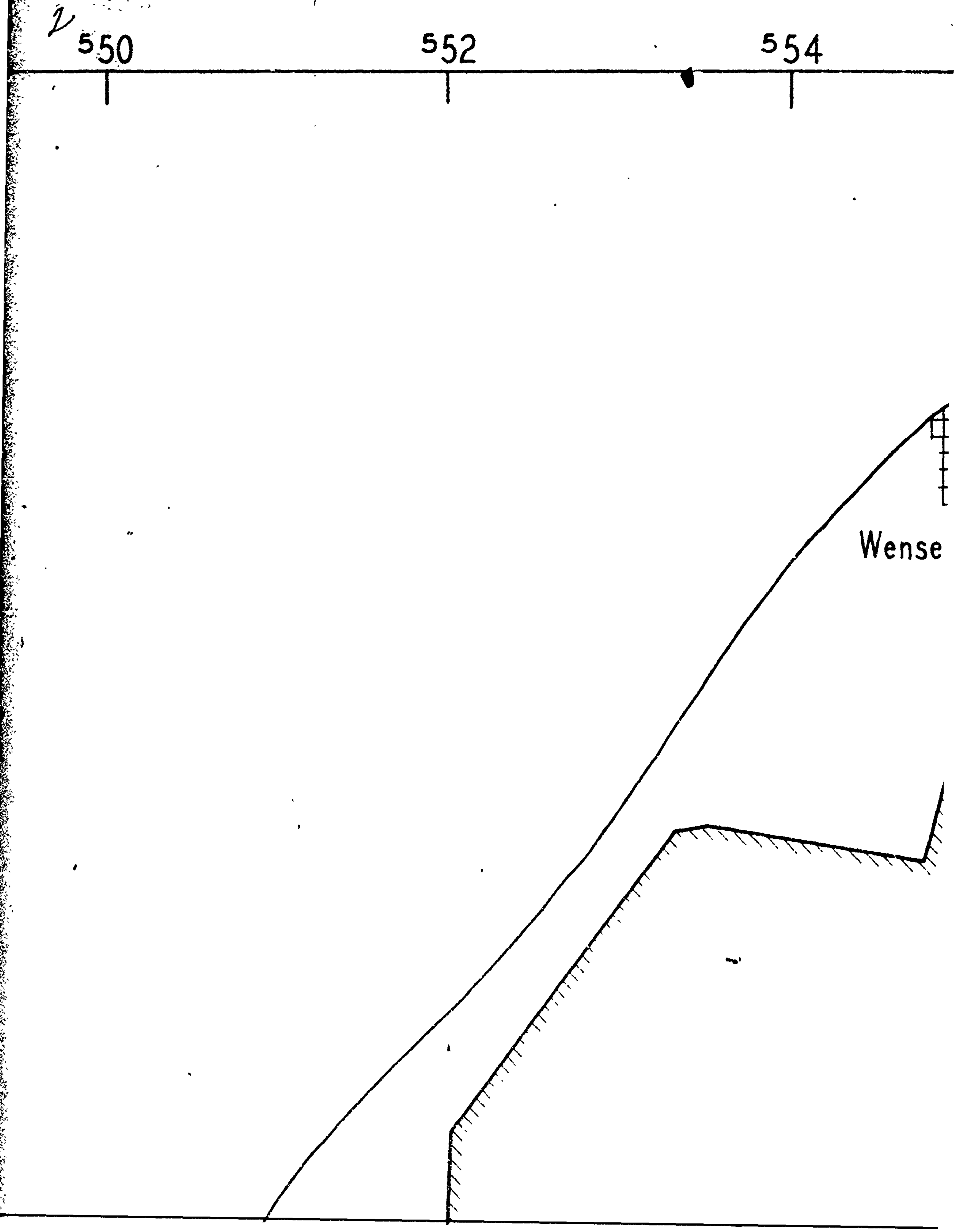
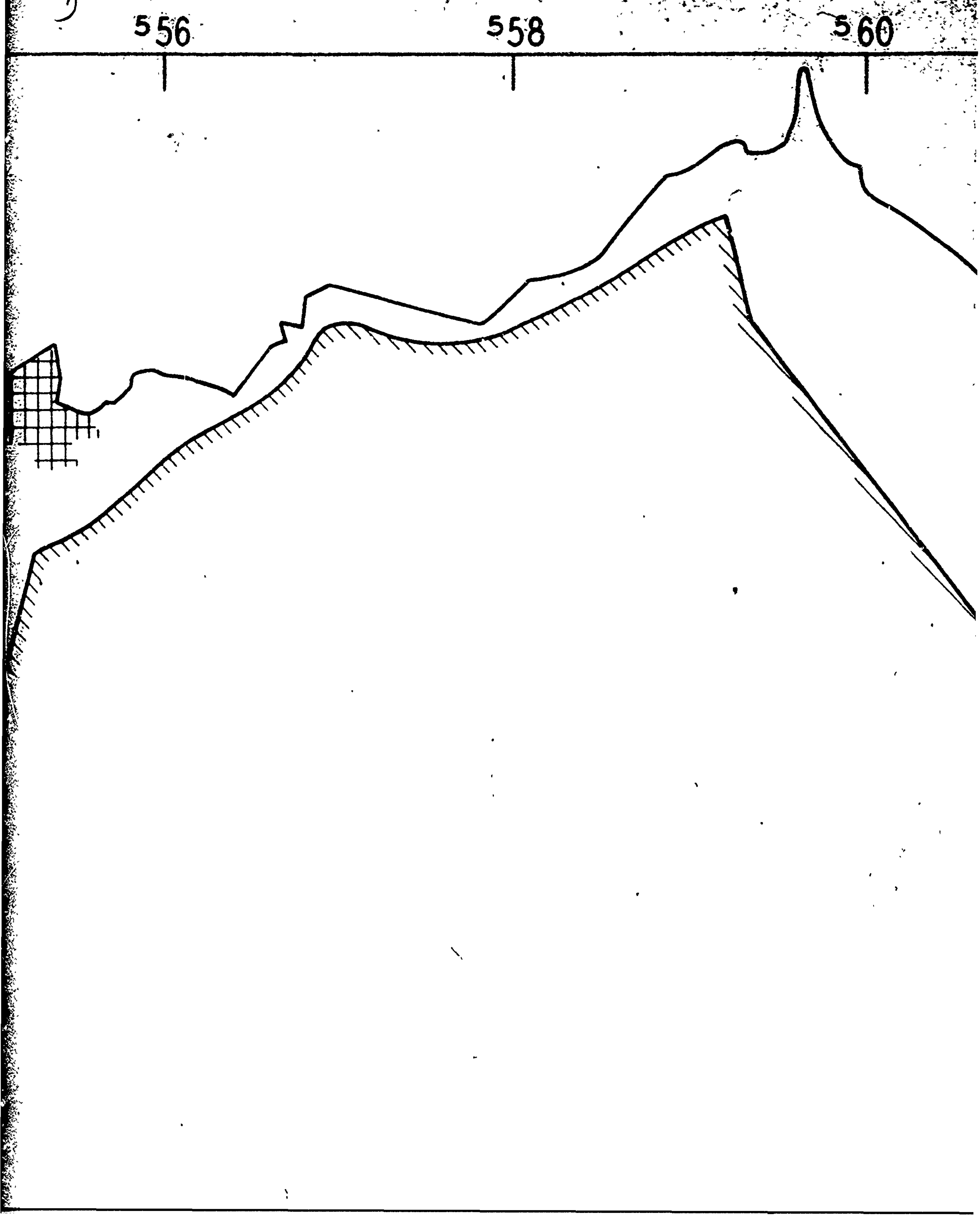
BERGEN HOHNE

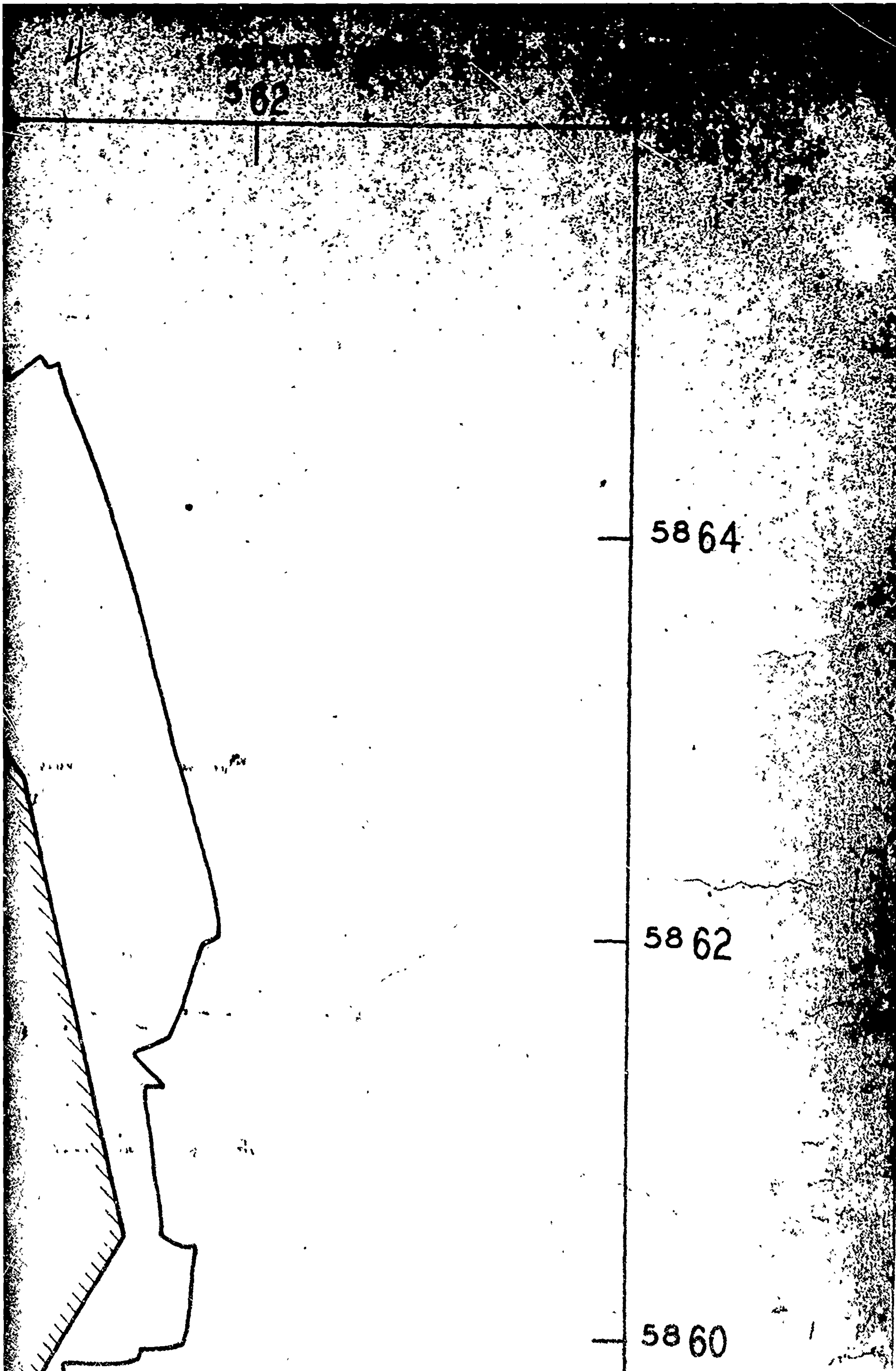
NATO CAMP BERGEN HOHNE





2
550
552
554
Wense


3
556
558
560



	S
Map Unit	SL
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1
16	1
17	1
18	1
19	1
20	1
21	1
22	1
23	1
24	1
25	1
26	1
27	1
28	1
29	1
30	1
31	1
32	1
33	1
34	1
35	1
36	1
37	1
38	1
39	1
40	1
41	1
42	1
43	1
44	1
45	1
46	1
47	1
48	1
49	1
50	1
51	1
52	1
53	1
54	1

5

LEGEND

ACE GEOMETRY			SURFACE COMPOSITION	VEGETATION							
				Spacing of Stems > the Specified Diameter, in.							
EA	IA	SH		1.0	2.5	4.0	5.5	7.0	8.5	10.0	Visibility
1/1	10/10	1/1	4M	3	3	3	3	3	4	6	7
1/1	10/10	1/1	4M	3	3	3	4	4	4	4	7
1/1	10/10	1/1	4M	4	4	4	4	4	4	4	7
1/1	10/10	1/1	4M	6	6	6	6	6	6	7	7
1/1	10/10	1/1	4M	7	7	7	7	7	7	7	7
1/1	10/10	1/1	6M	1	1	1	2	3	5	7	7
1/1	10/10	1/1	6M	1	1	2	2	4	6	7	2
1/1	10/10	1/1	6M	1	2	2	2	4	5	7	7
1/1	10/10	1/1	6M	1	2	7	7	7	7	7	3
1/1	10/10	1/1	6M	2	2	2	2	3	5	7	7
1/1	10/10	1/1	6M	2	3	3	4	4	4	4	2
1/1	10/10	1/1	6M	3	3	3	3	3	3	4	7
1/1	10/10	1/1	6M	4	4	4	4	4	4	4	7
1/1	10/10	1/1	6M	4	4	4	4	4	4	5	4
1/1	10/10	1/1	6M	6	6	6	6	6	6	7	7
1/1	10/10	1/1	6M	7	7	7	7	7	7	7	7
1/1	10/10	1/1	7	1	1	1	2	3	5	7	7
1/1	10/10	1/1	7	1	1	2	2	4	6	7	2
1/1	10/10	1/1	7	1	2	2	2	3	7	7	7
1/1	10/10	1/1	7	1	2	7	7	7	7	7	3
1/1	10/10	1/1	7	1	7	7	7	7	7	7	2
1/1	10/10	1/1	7	2	2	2	2	2	5	7	7
1/1	10/10	1/1	7	2	2	2	2	3	5	7	7
1/1	10/10	1/1	7	2	2	2	3	3	5	7	7
1/1	10/10	1/1	7	2	3	3	3	4	4	5	7
1/1	10/10	1/1	7	2	3	3	4	4	4	5	3
1/1	10/10	1/1	7	3	3	3	3	3	3	4	7
1/1	10/10	1/1	7	3	3	3	3	3	3	6	7
1/1	10/10	1/1	7	3	3	3	4	4	7	7	7
1/1	10/10	1/1	7	4	4	4	4	4	4	4	7
1/1	10/10	1/1	7	4	4	4	4	4	4	5	4
1/1	10/10	1/1	7	6	6	6	6	6	6	7	7
1/1	10/10	1/1	7	7	7	7	7	7	7	7	7
1/1	10/10	1/1	7S	1	1	1	2	3	5	7	7
1/1	10/10	1/1	7S	2	2	2	2	3	4	5	7
1/1	10/10	1/1	7S	2	3	3	4	4	4	4	2
1/1	10/10	1/1	7S	3	3	3	3	3	3	4	7
1/1	10/10	1/1	7S	3	3	3	3	3	4	6	7
1/1	10/10	1/1	7S	7	7	7	7	7	7	7	7
1/1	10/10	1/1	7S	4	4	4	4	4	4	5	4
1/1	10/10	2/2	3S	3	3	3	3	3	3	4	7
1/1	10/10	2/2	3S	7	7	7	7	7	7	7	7
1/1	10/10	2/2	4M	1	1	1	2	4	7	7	7
1/1	10/10	2/2	4M	1	2	7	7	7	7	7	3
1/1	10/10	2/2	4M	2	2	2	2	3	4	5	7
1/1	10/10	2/2	4M	3	3	3	3	3	4	6	7
1/1	10/10	2/2	4M	3	3	3	4	4	4	4	7
1/1	10/10	2/2	4M	4	4	4	4	4	4	4	7
1/1	10/10	2/2	4M	4	4	4	4	4	4	5	4
1/1	10.10	2/2	4M	6	6	6	6	6	6	7	7
1/1	10/10	2/2	4M	7	7	7	7	7	7	7	7
1/1	10/10	2/2	6M	1	1	1	2	3	5	7	7
1/1	10/10	2/2	6M	1	1	2	2	4	6	7	2
1/1	10/10	2/2	6M	1	2	7	7	7	7	7	3

Map Unit	SURFACE GEOMETRY				
	SL	OS	EA	IA	SH
218	1	1	3/3	7/5	
219	1	1	3/3	7/5	
220	1	1	3/3	7/5	
225	1	1	3/3	8/8	
226	1	1	3/3	8/8	
227	1	1	3/3	8/8	
228	1	1	3/3	10/10	
229	1	1	3/3	10/10	
230	1	1	3/3	10/10	
231	1	1	3/5	10/10	
232	1	1	3/5	10/10	
233	1	1	3/5	10/10	
234	1	1	3/5	10/10	
235	1	1	3/5	10/10	
236	1	1	3/5	10/10	
237	1	1	3/5	10/10	
238	1	1	4/2	10/10	
239	1	1	4/2	10/10	
240	1	1	10/9	10/10	
240	1	1	10/9	10/10	
241	1	1	10/9	10/10	
242	1	1	10/9	10/10	
243	1	1	10/9	10/10	
244	1	4	2/2	10/10	
245	1	4	2/2	10/10	
246	2	1	1/1	10/10	
247	2	1	1/1	10/10	
248	2	1	1/1	10/10	
249	2	1	1/1	10/10	
250	2	1	1/1	10/10	
251	2	1	1/1	10/10	
252	2	1	1/1	10/10	
253	2	1	1/1	10/10	
254	2	1	1/1	10/10	
255	2	1	1/1	10/10	
256	2	1	1/1	10/10	
257	2	1	1/1	10/10	
258	2	1	1/1	10/10	
250	2	1	1/1	10/10	
260	2	1	3/3	7/5	
261	2	1	3/3	7/5	
262	2	1	3/3	7/5	
263	2	1	3/3	7/5	
264	2	1	3/3	7/5	
265	2	1	3/3	7/5	
266	2	1	3/3	7/5	
267	2	1	3/3	7/5	
268	2	1	3/3	7/5	
269	2	1	3/3	7/5	
270	2	1	3/3	7/5	
271	2	1	3/3	7/5	
272	2	1	3/3	7/5	
273	2	1	3/3	7/5	
274	2	1	3/3	7/5	
275	2	1	3/3	7/5	

SURFACE GEOMETRY					SURFACE COMPOSITION	VEGETATION: Spacing of Stems > the Specified Diameter, in.							VEGETATION
SL	OS	EA	IA	SH		1.0	2.5	4.0	5.5	7.0	8.5	10.0	Visibility
1	1	3/3	7/5	1/1	7S	7	7	7	7	7	7	7	7
1	1	3/3	7/5	1/1	7	7	7	7	7	7	7	7	7
1	1	3/3	7/5	1/1	7	7	7	7	7	7	7	7	7
1	1	3/3	8/8	2/2	7	4	4	4	4	4	4	5	7
1	1	3/3	8/8	2/2	7	7	7	7	7	7	7	7	7
1	1	3/3	8/8	2/2	7S	7	7	7	7	7	7	7	7
1	1	3/3	10/10	7/7	4M	7	7	7	7	7	7	7	7
1	1	3/3	10/10	7/7	5M	7	7	7	7	7	7	7	7
1	1	3/3	10/10	8/8	5M	7	7	7	7	7	7	7	7
1	1	3/5	10/10	6/7	3S	3	3	3	3	3	3	4	7
1	1	3/5	10/10	6/7	3S	7	7	7	7	7	7	7	7
1	1	3/5	10/10	6/7	5M	7	7	7	7	7	7	7	7
1	1	3/5	10/10	6/7	6M	7	7	7	7	7	7	7	7
1	1	3/5	10/10	6/7	7	7	7	7	7	7	7	7	7
1	1	3/5	10/10	6/7	7S	1	2	7	7	7	7	7	7
1	1	3/5	10/10	6/7	7S	7	7	7	7	7	7	7	7
1	1	4/2	10/10	1/1	6M	6	6	6	6	6	6	7	7
1	1	4/2	10/10	1/1	6M	7	7	7	7	7	7	7	7
1	1	10/9	10/10	8/6	7	4	4	4	4	4	4	4	7
1	1	10/9	10/10	8/6	7	4	4	4	4	4	4	4	7
1	1	10/9	10/10	8/6	7	7	7	7	7	7	7	7	7
1	1	10/9	10/10	8/6	7S	1	1	1	2	3	5	7	7
1	1	10/9	10/10	8/6	7S	7	7	7	7	7	7	7	7
1	4	2/2	10/10	8/8	7	7	7	7	7	7	7	7	7
1	4	2/2	10/10	8/8	7S	7	7	7	7	7	7	7	7
2	1	1/1	10/10	2/2	6M	1	1	1	2	3	5	7	7
2	1	1/1	10/10	2/2	6M	1	1	2	2	4	6	7	2
2	1	1/1	10/10	2/2	6M	1	2	7	7	7	7	7	3
2	1	1/1	10/10	2/2	6M	2	3	3	4	4	4	4	2
2	1	1/1	10/10	2/2	6M	7	7	7	7	7	7	7	7
2	1	1/1	10/10	2/2	7	1	1	1	2	3	5	7	7
2	1	1/1	10/10	2/2	7	1	2	7	7	7	7	7	3
2	1	1/1	10/10	2/2	7	2	2	2	2	3	5	7	7
2	1	1/1	10/10	2/2	7	2	3	3	4	4	4	5	3
2	1	1/1	10/10	2/2	7	3	3	3	3	3	3	4	7
2	1	1/1	10/10	2/2	7	3	3	3	3	3	4	6	7
2	1	1/1	10/10	2/2	7	3	3	3	4	4	7	7	7
2	1	1/1	10/10	2/2	7	4	4	4	4	4	4	4	7
2	1	1/1	10/10	2/2	7	7	7	7	7	7	7	7	7
2	1	3/3	7/5	1/1	3S	7	7	7	7	7	7	7	7
2	1	3/3	7/5	1/1	6M	6	6	6	6	6	6	6	7
2	1	3/3	7/5	1/1	6M	7	7	7	7	7	7	7	7
2	1	3/3	7/5	1/1	7	1	1	1	2	3	5	7	7
2	1	3/3	7/5	1/1	7	1	2	2	2	3	7	7	7
2	1	3/3	7/5	1/1	7	1	2	7	7	7	7	7	3
2	1	3/3	7/5	1/1	7	1	3	7	7	7	7	7	2
2	1	3/3	7/5	1/1	7	2	2	2	2	2	5	7	7
2	1	3/3	7/5	1/1	7	2	2	2	2	3	4	5	7
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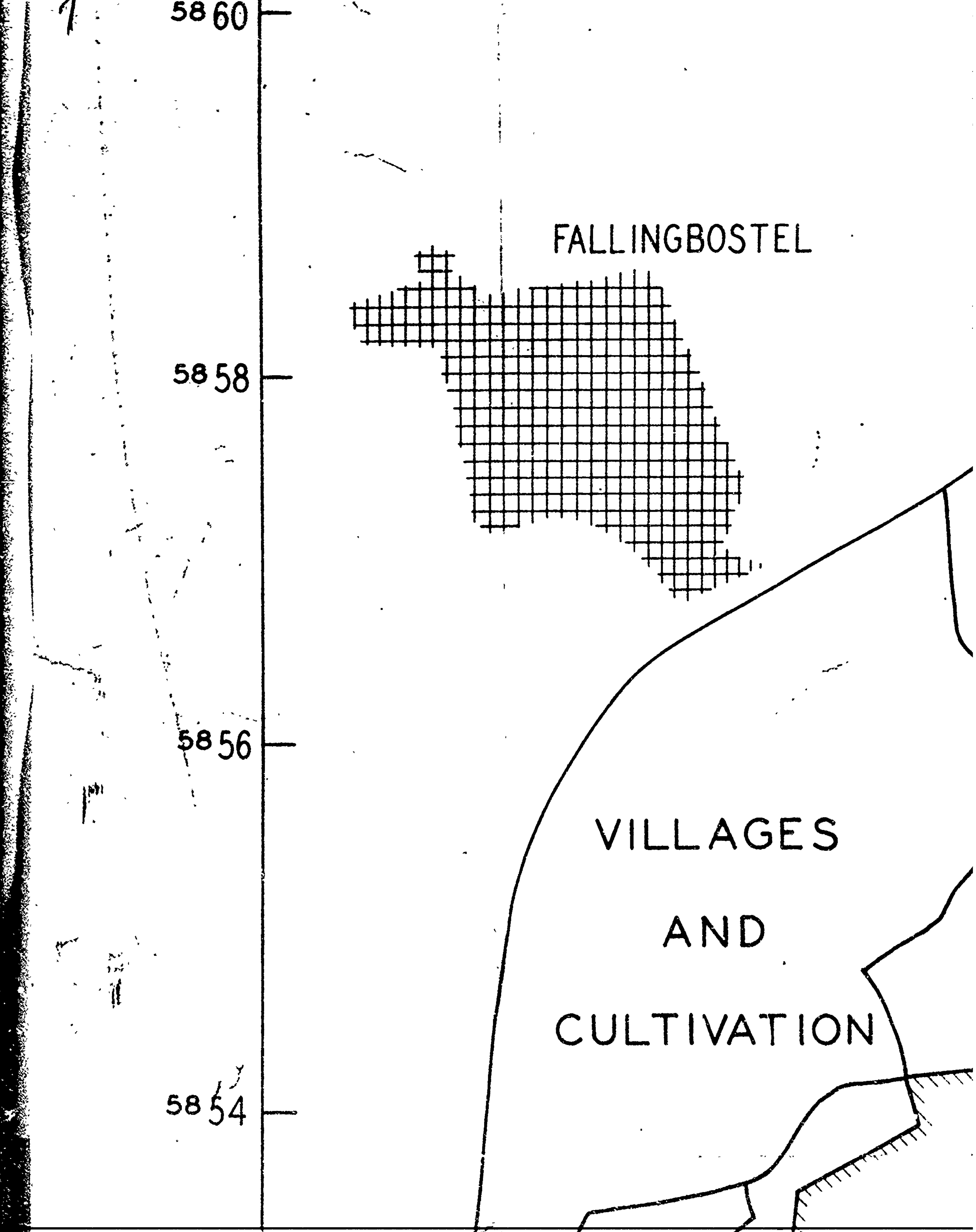
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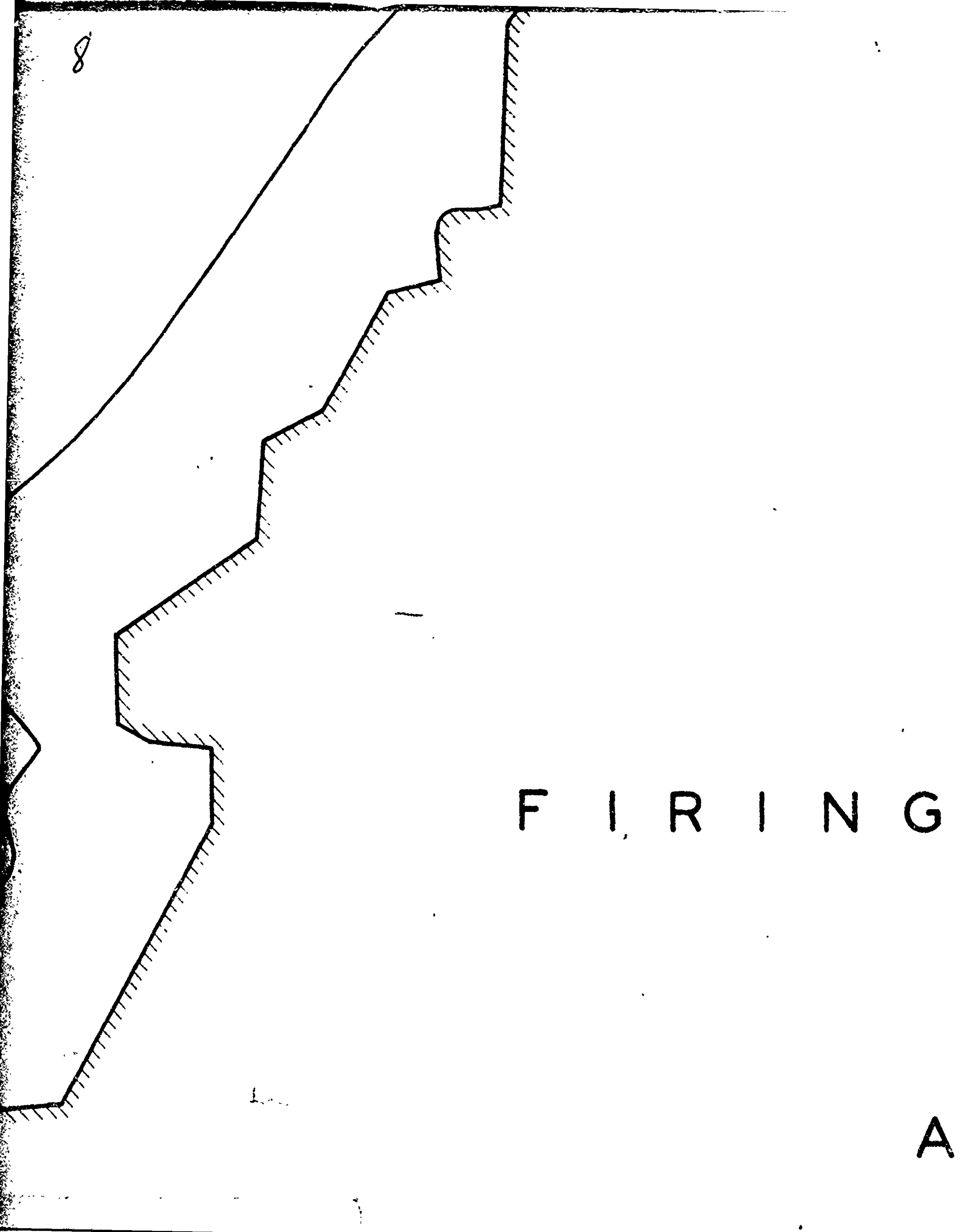

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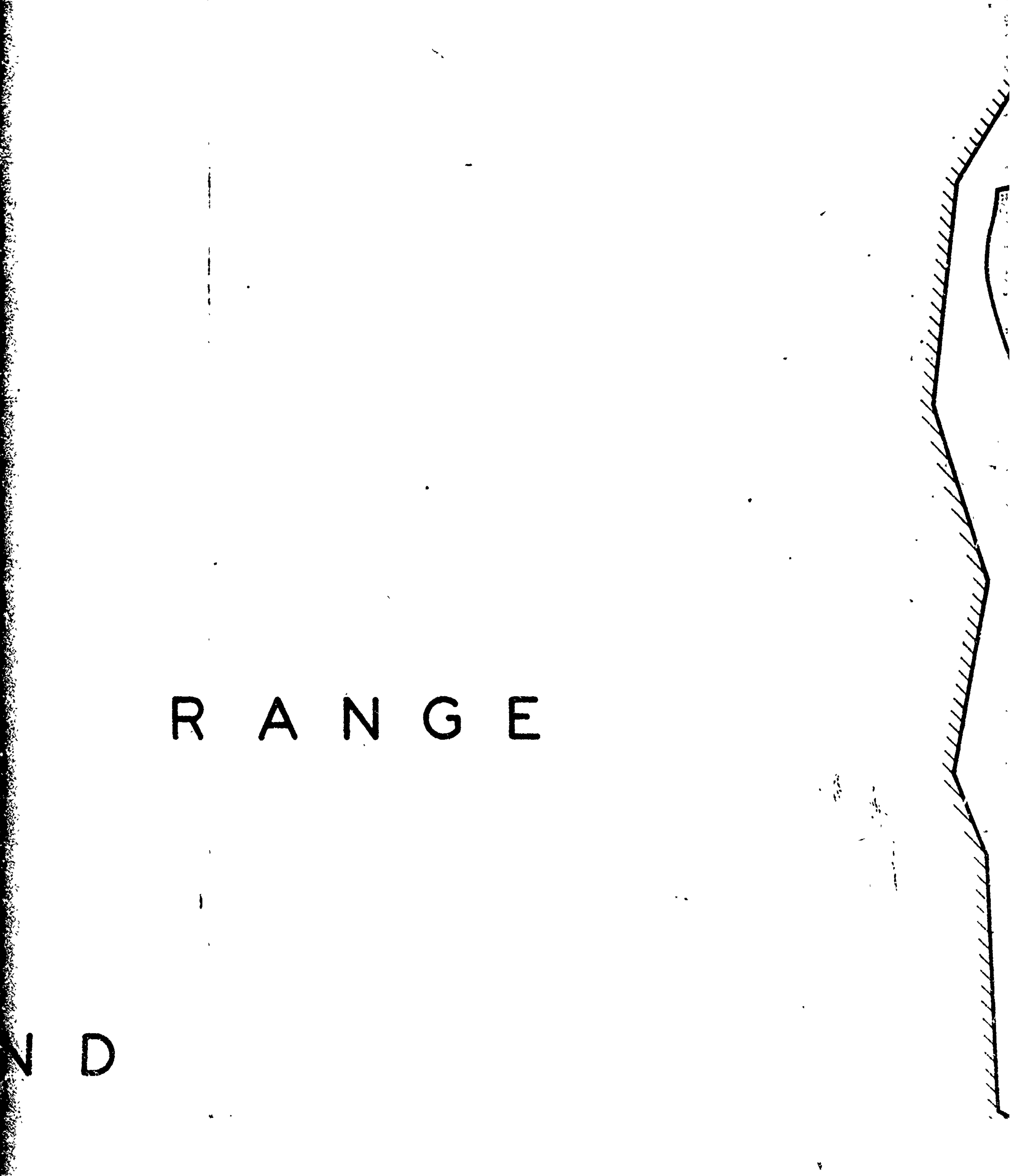

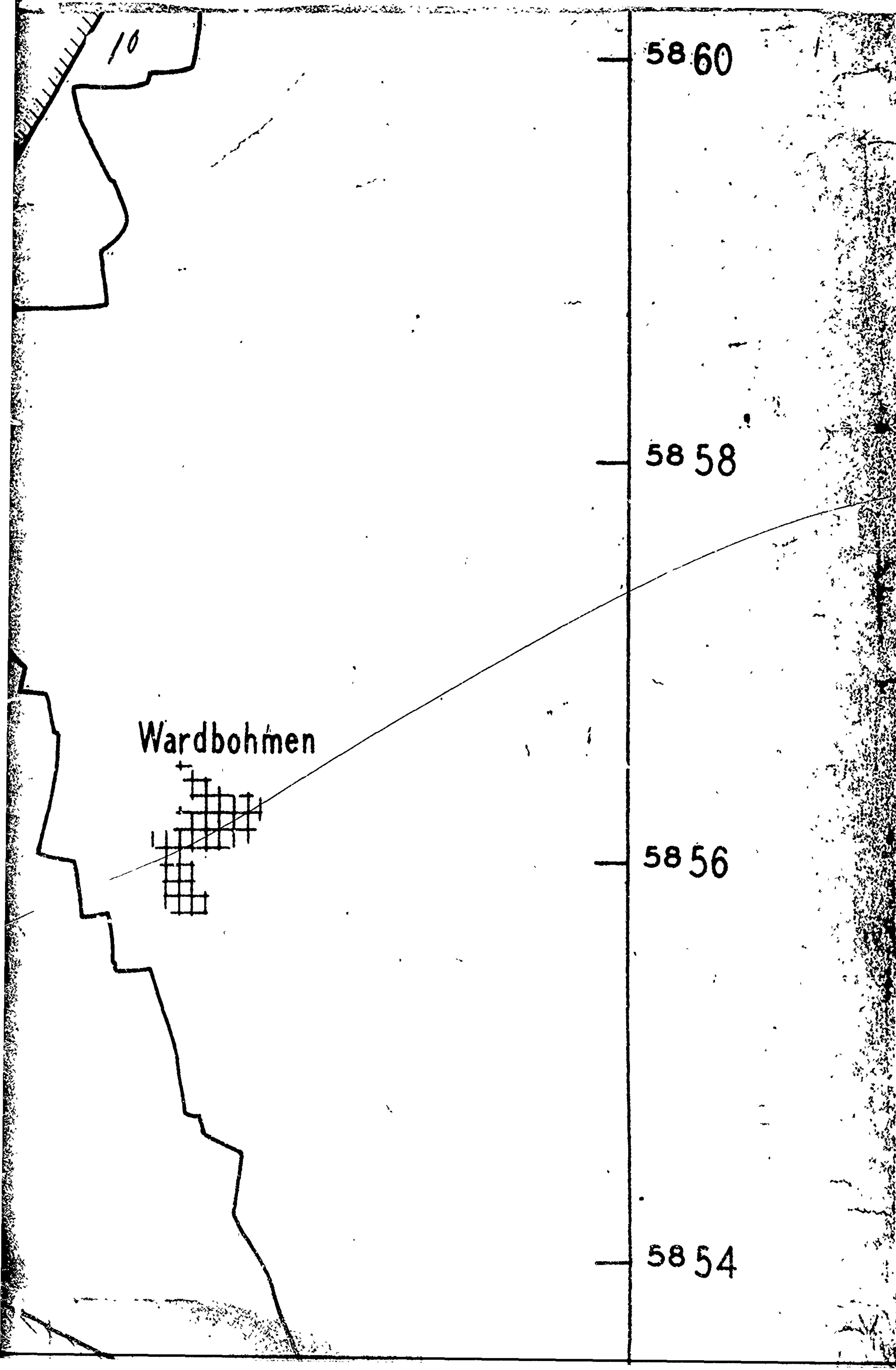

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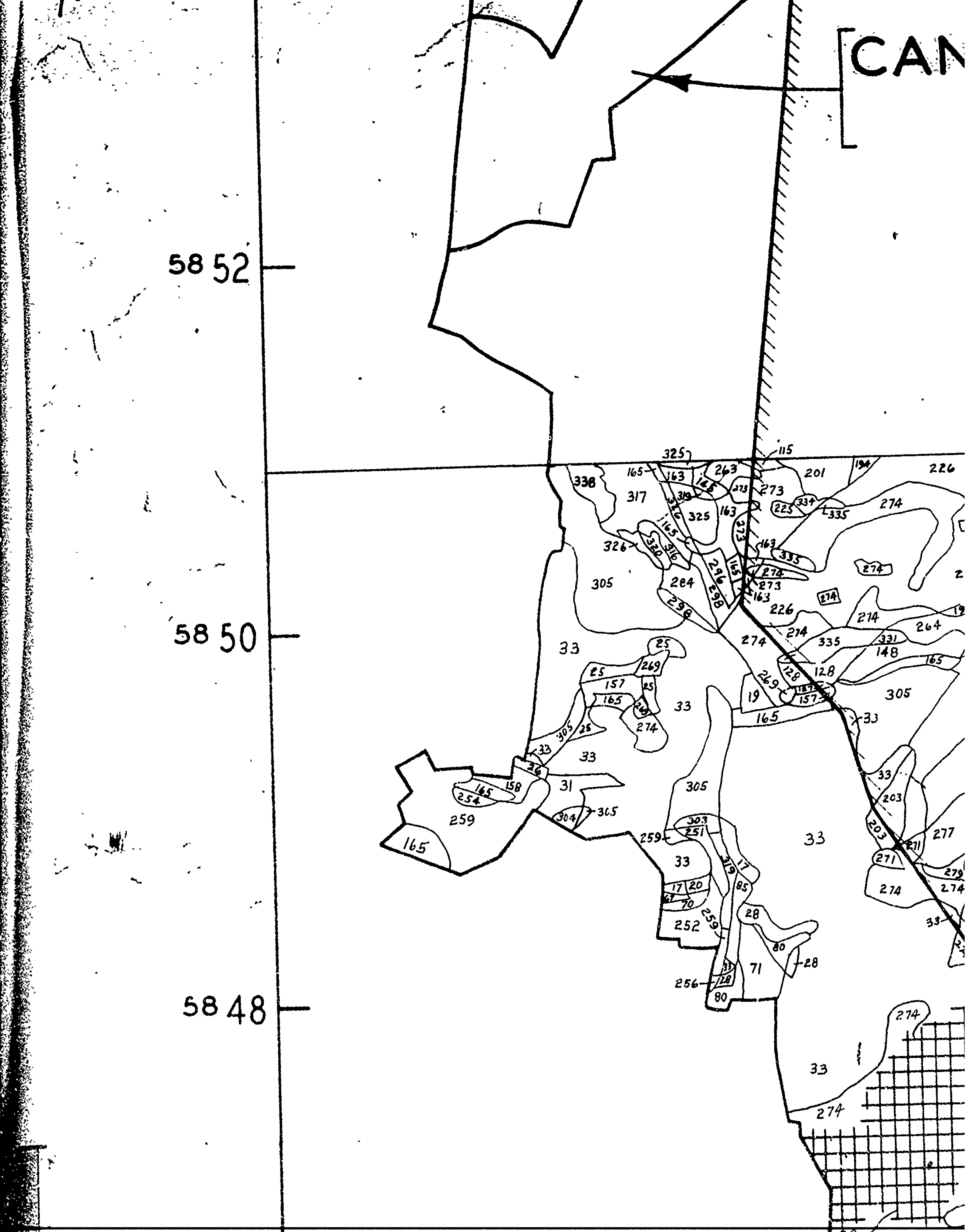

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ONMENT
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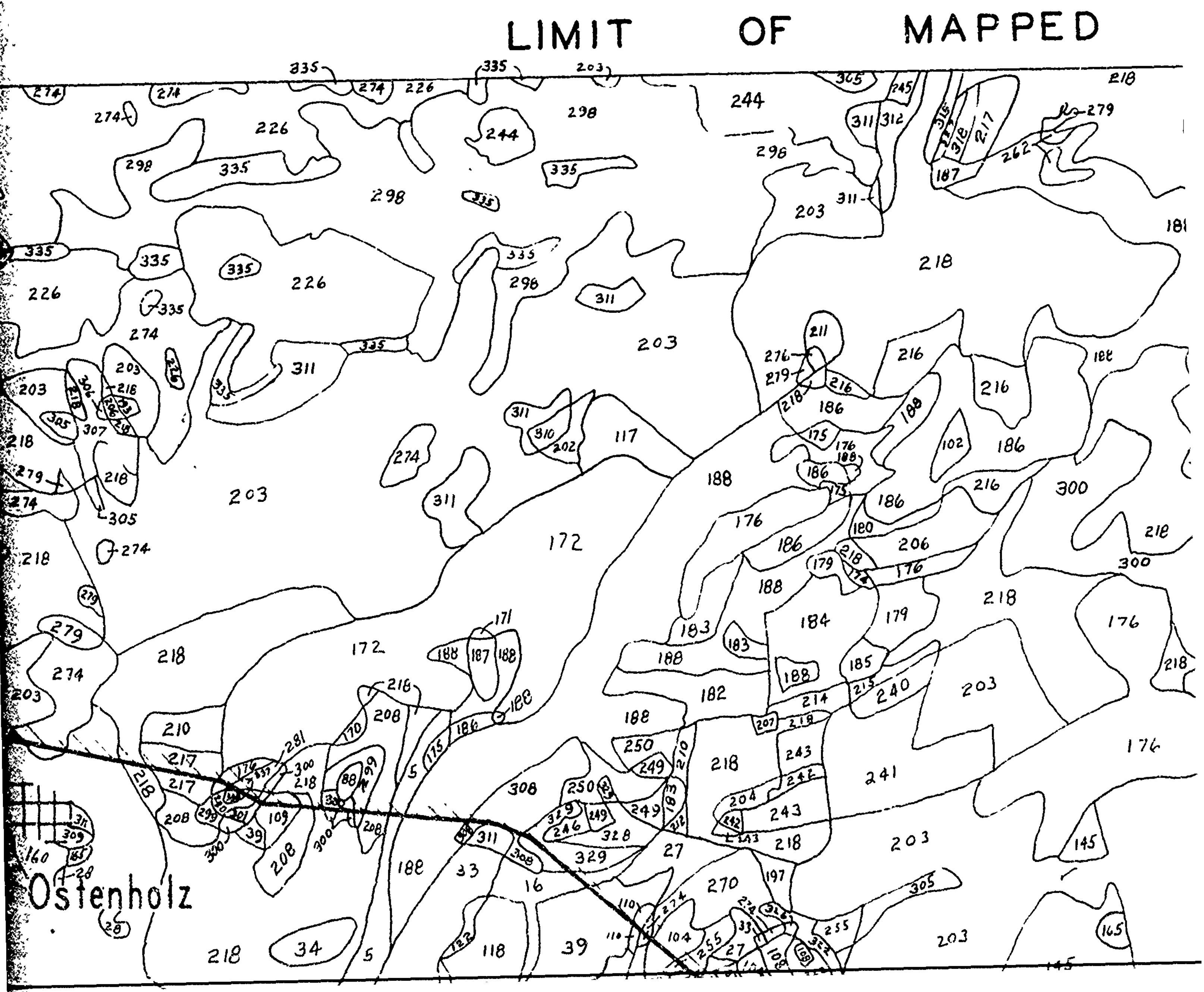

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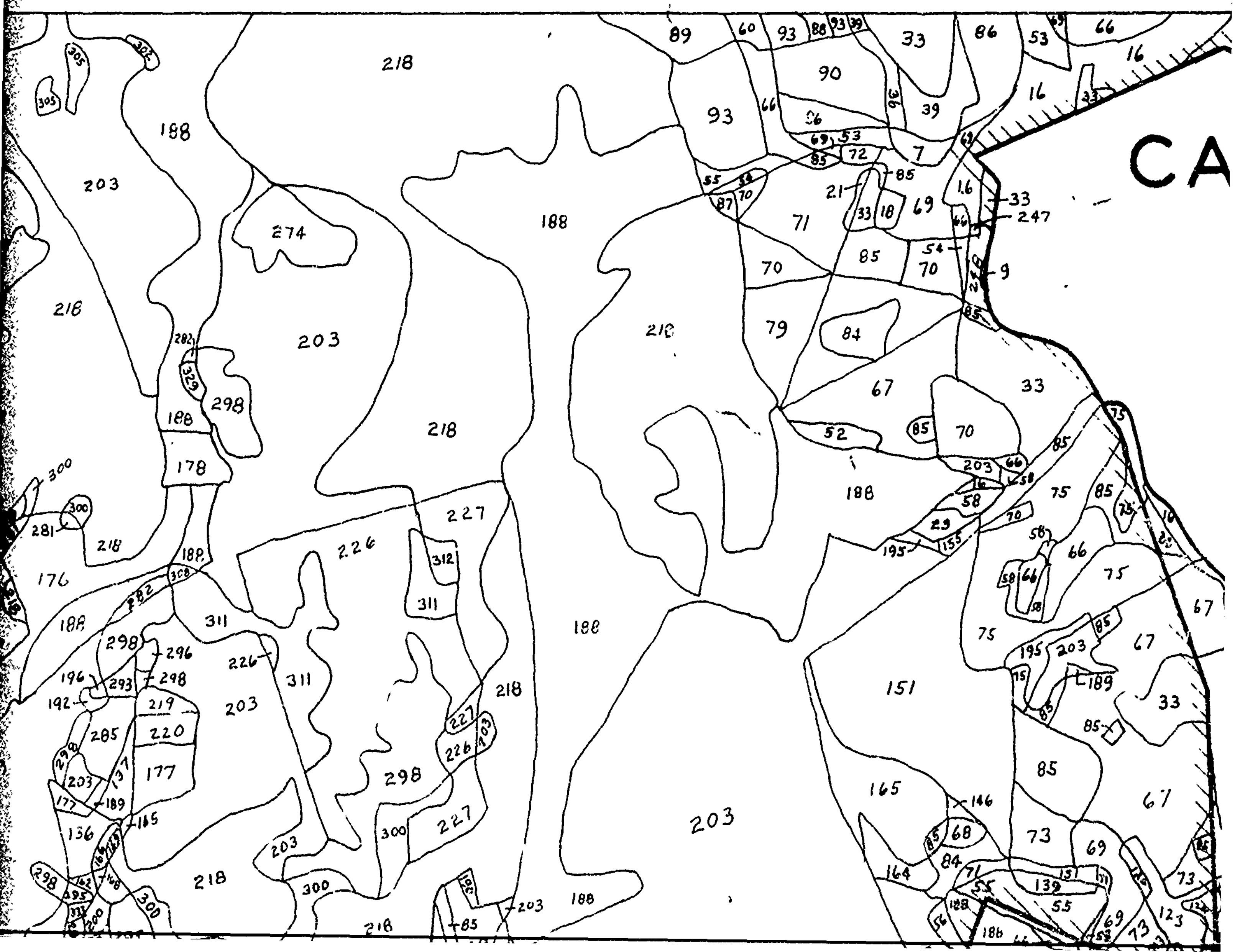
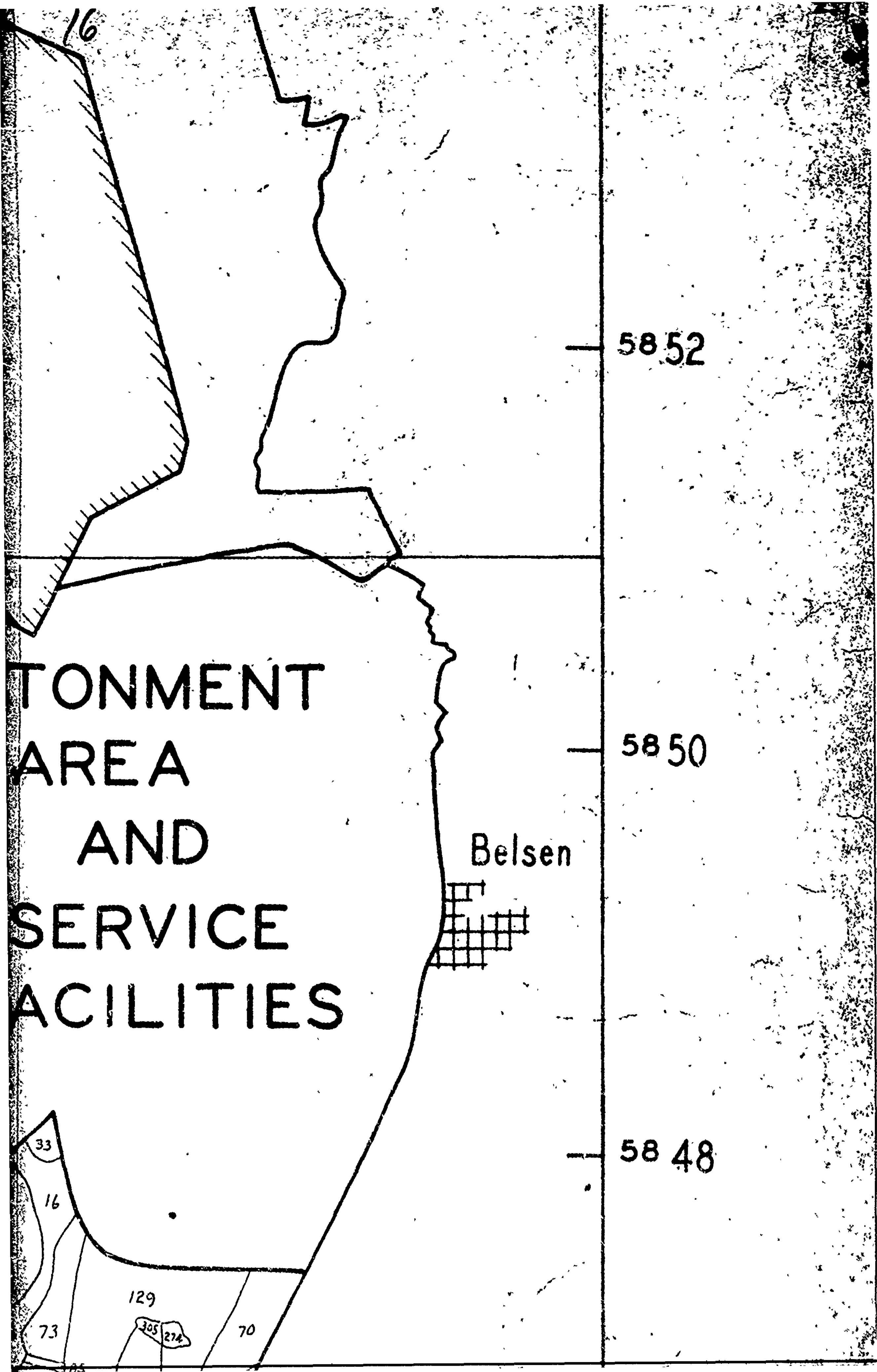
A R E A

AREA





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4/3	1/1	7	1	7	7	7	7	7	7	2
4/3	1/1	7	2	2	2	2	2	2	3	7
4/3	1/1	7	2	2	2	2	2	5	7	7
4/3	1/1	7	2	2	2	2	3	4	5	7
4/3	1/1	7	2	2	2	2	3	5	7	7
4/3	1/1	7	2	2	2	3	3	6	7	7
4/3	1/1	7	2	3	3	3	4	4	5	7
4/3	1/1	7	2	3	3	4	4	4	5	3
4/3	1/1	7	3	3	3	3	3	3	4	7
4/3	1/1	7	3	3	3	3	3	4	6	7
4/3	1/1	7	3	3	3	4	4	4	5	7
4/3	1/1	7	4	4	4	4	4	4	4	7
4/3	1/1	7	4	4	4	4	4	4	5	4
4/3	1/1	7	6	6	6	6	6	6	7	7
4/3	1/1	7	7	7	7	7	7	7	7	7
4/3	1/1	7S	1	2	2	2	4	5	7	7
4/3	1/1	7S	1	2	7	7	7	7	7	3
4/3	1/1	7	4	4	4	4	4	4	4	7
4/3	1/1	7S	7	7	7	7	7	7	7	7
7/5	1/1	3M	2	2	2	2	2	3	3	7
7/5	1/1	3M	6	6	6	6	6	6	7	7
7/5	1/1	3M	7	7	7	7	7	7	7	7
7/5	1/1	3S	7	7	7	7	7	7	7	7
7/5	1/1	4M	1	2	2	2	4	5	7	7
7/5	1/1	4M	4	4	4	4	4	4	5	4

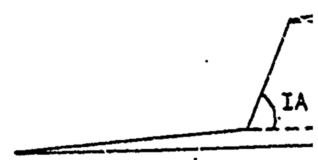
334	3	1	3/3	8/8	2/2
335	3	1	3/3	8/8	2/2
336	3	2	2/2	5/5	2/2
337	3	2	2/2	5/5	2/2
338	3	2	2/2	5/5	2/2
339	3	2	2/2	5/5	2/2

◊Each map unit represents a
mapping classes of slope. SL
EA and IA, and step height
were mapped. The numerator
countered while traversing
180 deg) and the denominato
to 360 deg) assuming that

*Mapping class ranges of ea

Slope (SL)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31

Spa
Map Class
1
2
3
4



**Mapping class ra

Map Class	6-12 i RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

***Mapping class rang

Stem Spac
Map

[illegible]	3	1	3/3	8/8	2/2	7	1	2	2	2	3	7	[illegible]	[illegible]
[illegible]	3	1	3/3	8/8	2/2	7	3	3	3	3	3	3	4	7
[illegible]	3	1	3/3	8/8	2/2	7	4	4	4	4	4	4	4	7
[illegible]	3	1	3/3	8/8	2/2	7	4	4	4	4	4	4	5	4
[illegible]	3	1	3/3	8/8	2/2	7	7	7	7	7	7	7	7	7
[illegible]	3	2	2/2	5/5	2/2	4M	2	2	2	2	2	3	3	7
37	3	2	2/2	5/5	2/2	4M	7	7	7	7	7	7	7	7
38	3	2	2/2	5/5	2/2	7	7	7	7	7	7	7	7	7
39	3	2	2/2	5/5	2/2	7S	7	7	7	7	7	7	7	7

18

♦Each map unit represents an array of symbols [i.e. 1,1,(1/1 10/10),2/2] indicating mapping classes of slope SL (see diagram below) obstacle spacing OS, approach angle EA and IA, and step height SH. Fractional designations indicate that dual classes were mapped. The numerator of the fraction indicates class range that will be encountered while traversing an area in an easterly direction (i.e. azimuth from >0 to 180 deg) and the denominator refers to a westerly direction (i.e. azimuth from >180 to 360 deg) assuming that the vehicle intersects the obstacle at a right angle.

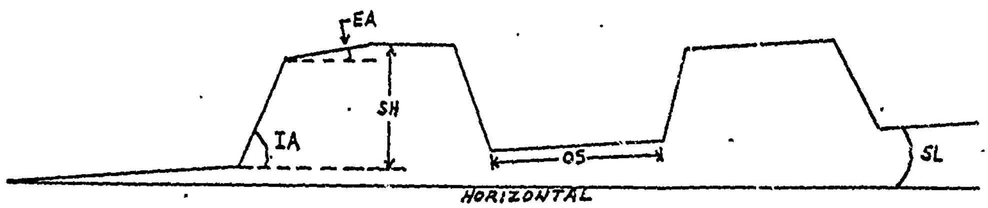
*Mapping class ranges of each surface geometry factor are:

Slope (SL)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31

Spacing (OS)	
Map Class	ft
1	0-50
2	>50-150
3	>150-225
4	>225

Approach Angle (EA-IA)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45

Step Height (SH)	
Map Class	in
1	<8
2	8-10
3	>10-12
4	>12-14
5	>14-16
6	>16-20
7	>20-30
8	>30



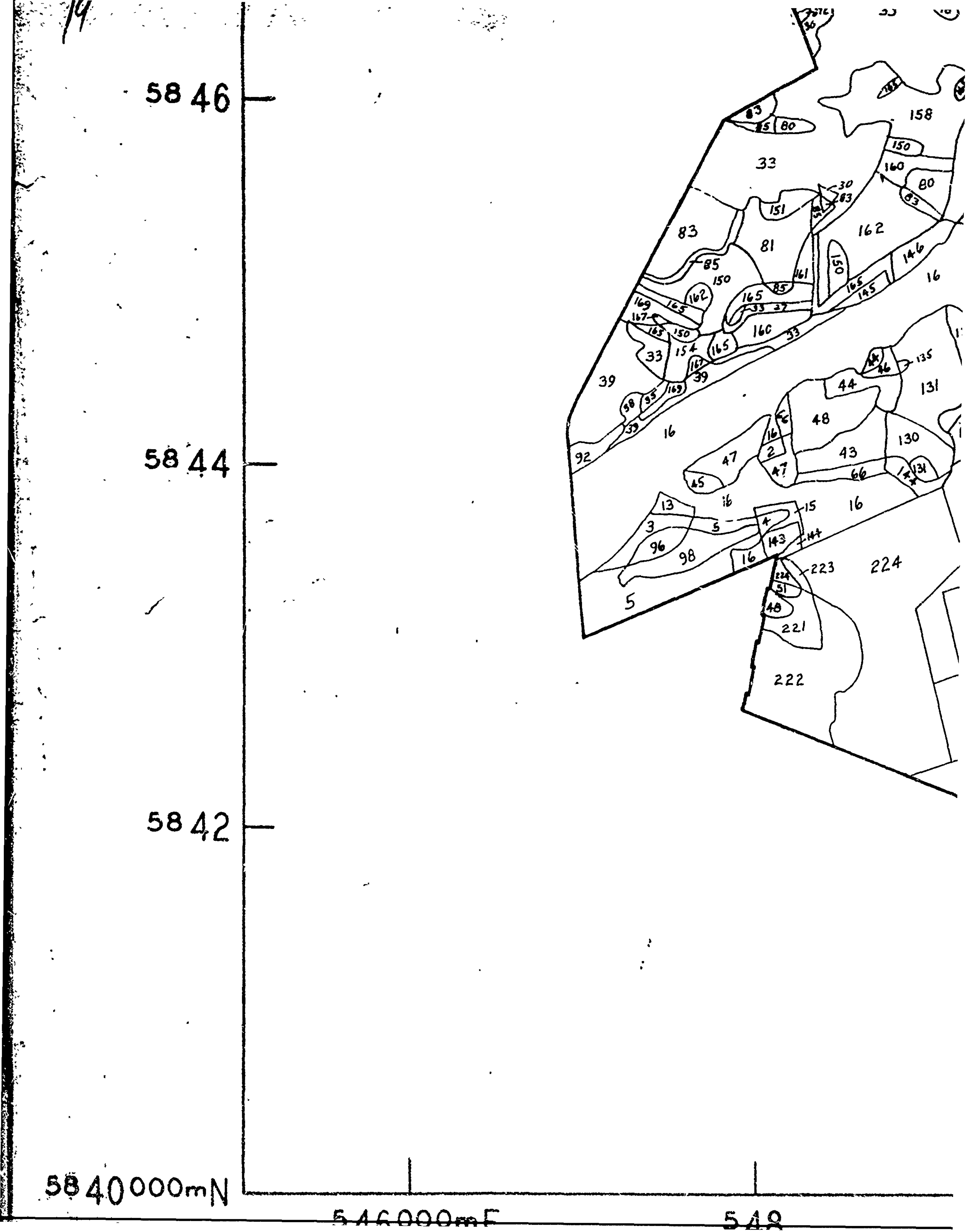
**Mapping class ranges for each Surface Composition unit are:

Map Class	6-12 in RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

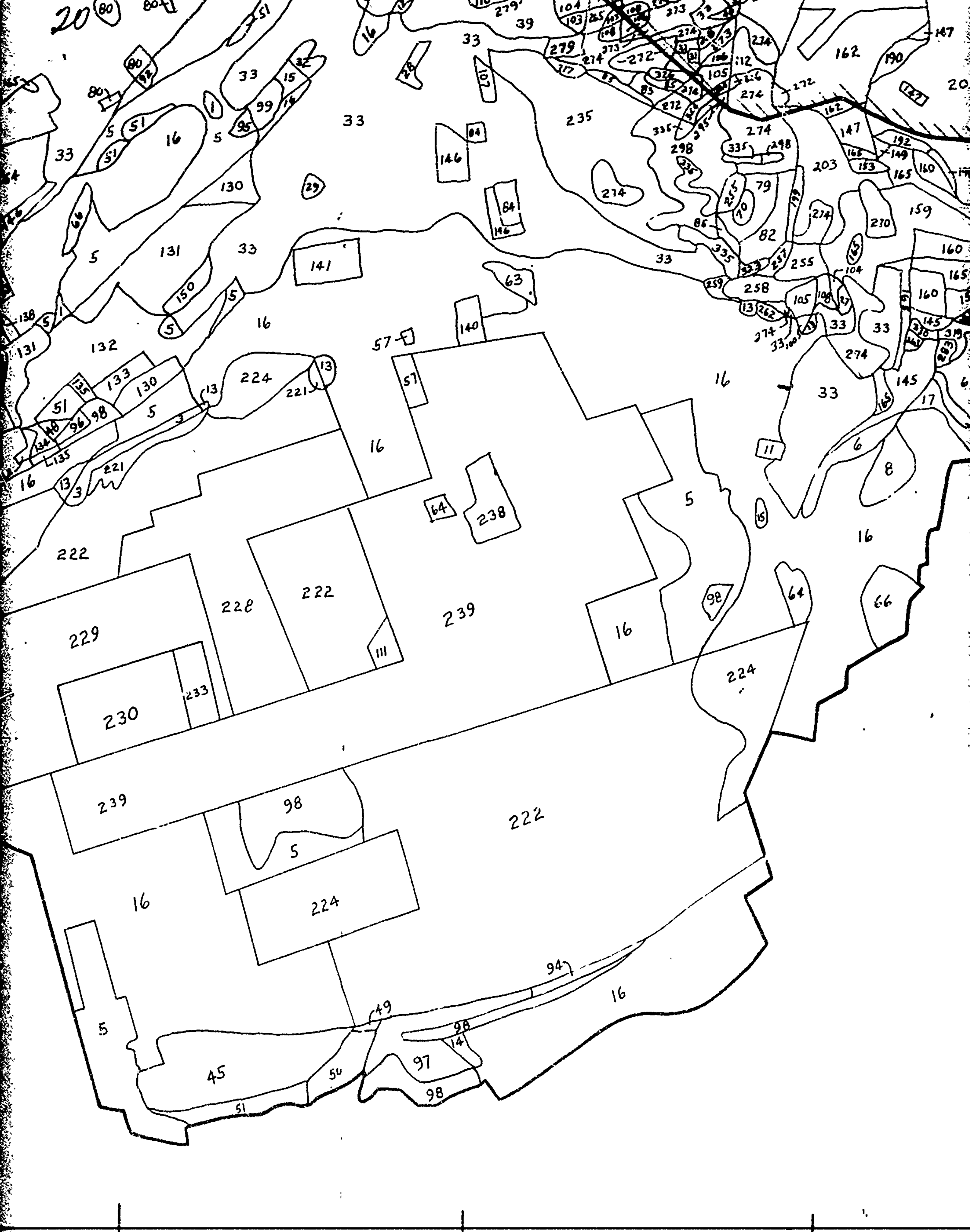
Map Class	0-6 in CI
1S	0-20
2S	>20-40
3S	>40-75
4S	>75-125
5S	>125-175
6S	>175-250
7S	>250

Map Class	6-12 in CI
1M	0-15
2M	>15-30
3M	>30-45
4M	>45-60
5M	>60-80
6M	>80

***Mapping class ranges for each spacing class and visibility class are:



14
58 46
58 44
58 42
5840000mN
546000mE
548



20
33
235
162
147
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131
132
133
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140
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224
221
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134
222
228
229
230
233
239
238
64
111
11
15
8
6
17
145
274
255
258
105
82
79
203
159
160
165
210
66
98
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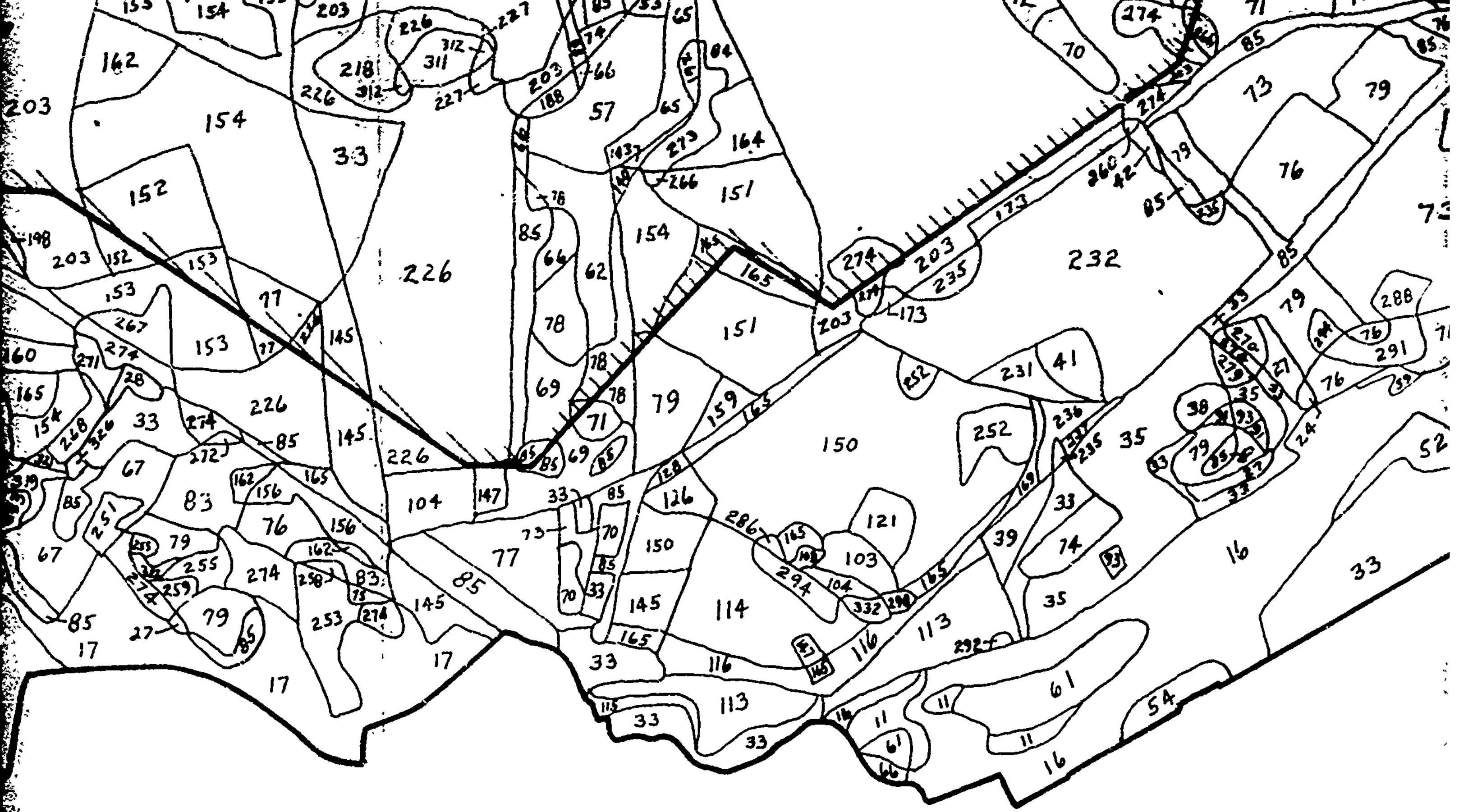
49
94
97
14



203
162
154
218
311
226
57
33
164
151
152
154
85
62
66
78
226
232
73
79
76
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274
203
235
153
267
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145
151
165
173
41
231
252
288
291
153
226
79
69
71
159
150
236
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52
165
154
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83
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76
274
104
147
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126
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121
103
114
145
294
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74
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85
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253
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113
116
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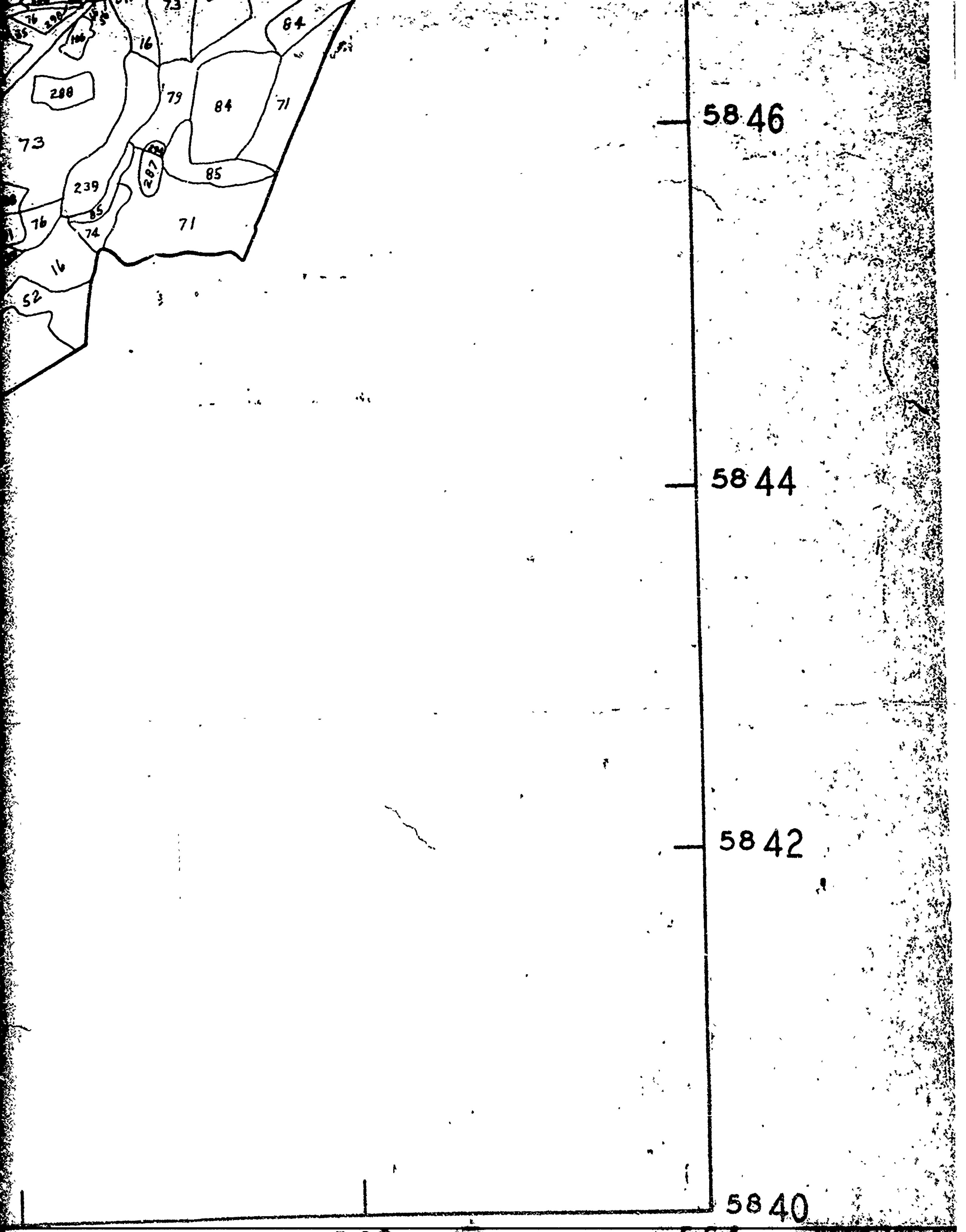
11
16



84
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288
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287
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239
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76
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71
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52
58 46
58 44
58 42
58 40

176	1	1	3/3	7/5	1/1	4M	7	7	7	7	7	7	7	7
177	1	1	3/3	7/5	1/1	5	7	7	7	7	7	7	7	7
178	1	1	3/3	7/5	1/1	5M	7	7	7	7	7	7	7	7
179	1	1	3/3	7/5	1/1	6M	1	2	2	2	4	5	7	7
180	1	1	3/3	7/5	1/1	6M	1	2	7	7	7	7	7	3
181	1	1	3/3	7/5	1/1	6M	2	2	2	2	2	5	7	7
182	1	1	3/3	7/5	1/1	6M	2	2	2	2	3	4	5	7
183	1	1	3/3	7/5	1/1	6M	2	3	3	4	4	4	4	2
184	1	1	3/3	7/5	1/1	6M	3	3	3	4	4	7	7	7
185	1	1	3/3	7/5	1/1	6M	4	4	4	4	4	4	4	7
186	1	1	3/3	7/5	1/1	6M	4	4	4	4	4	4	5	4
187	1	1	3/3	7/5	1/1	6M	6	6	6	6	6	6	7	7
188	1	1	3/3	7/5	1/1	6M	7	7	7	7	7	7	7	7
189	1	1	3/3	7/5	1/1	7	1	1	1	2	3	5	7	7
190	1	1	3/3	7/5	1/1	7	1	1	2	2	4	6	7	2
191	1	1	3/3	7/5	1/1	7	1	2	2	2	3	7	7	7
192	1	1	3/3	7/5	1/1	7	1	2	2	2	4	5	7	7
193	1	1	3/3	7/5	1/1	7	1	2	7	7	7	7	7	3
194	1	1	3/3	7/5	1/1	7	1	3	7	7	7	7	7	2
195	1	1	3/3	7/5	1/1	7	2	2	2	2	3	5	7	7
196	1	1	3/3	7/5	1/1	7	2	3	3	4	4	4	5	3
197	1	1	3/3	7/5	1/1	7	3	3	3	3	3	3	4	7
198	1	1	3/3	7/5	1/1	7	3	3	3	3	3	4	6	7
199	1	1	3/3	7/5	1/1	7	3	3	3	4	4	7	7	7
200	1	1	3/3	7/5	1/1	7	4	4	4	4	4	4	4	7
201	1	1	3/3	7/5	1/1	7	4	4	4	4	4	4	5	4
202	1	1	3/3	7/5	1/1	7	6	6	6	6	6	6	7	7
203	1	1	3/3	7/5	1/1	7	7	7	7	7	7	7	7	7
204	1	1	3/3	7/5	1/1	7S	1	1	1	2	3	5	7	7
205	1	1	3/3	7/5	1/1	7S	1	1	2	2	4	6	7	2
206q	1	1	3/3	7/5	1/1	7S	1	2	7	7	7	7	7	3
207	1	1	3/3	7/5	1/1	7S	1	3	7	7	7	7	7	2
208	1	1	3/3	7/5	1/1	7S	2	2	2	2	2	3	3	7
209	1	1	3/3	7/5	1/1	7S	2	3	3	3	4	4	5	7
210	1	1	3/3	7/5	1/1	7S	2	3	3	4	4	4	4	2
211	1	1	3/3	7/5	1/1	7S	2	3	3	4	4	4	5	3
212	1	1	3/3	7/5	1/1	7S	3	3	3	3	3	3	4	7
213	1	1	3/3	7/5	1/1	7S	3	3	3	3	3	4	6	7
214	1	1	3/3	7/5	1/1	7S	3	3	3	4	4	7	7	7
215	1	1	3/3	7/5	1/1	7S	4	4	4	4	4	4	4	[illegible]
216	1	1	3/3	7/5	1/1	7S	4	4	4	4	4	4	5	[illegible]
217	1	1	3/3	7/5	1/1	7S	6	6	6	6	6	6	7	

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7
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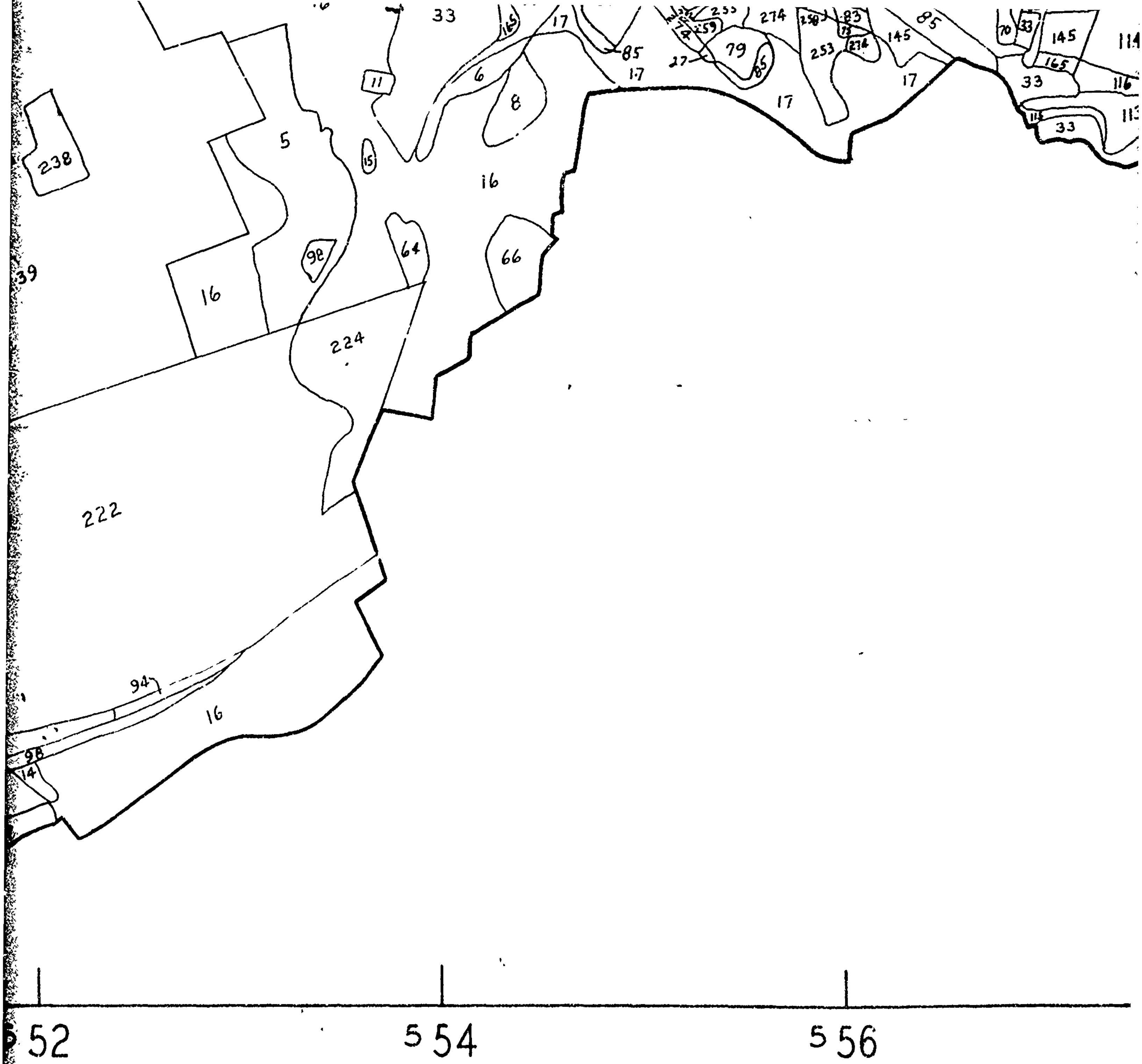
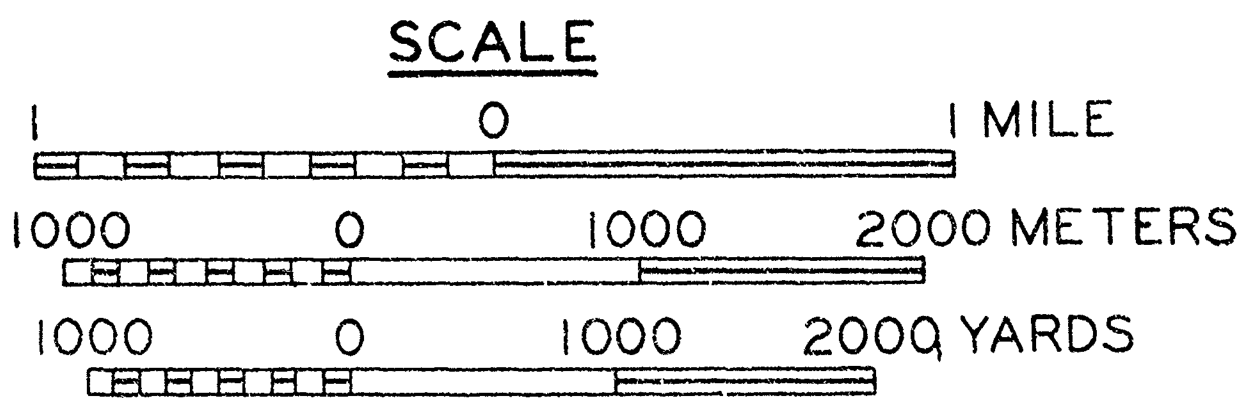
7
7
2
3
2
7
7
2
3
7
7
7
7
4
7

Mapping class ranges for each spacing class and visibility class are:

Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

Visibility	
Map Class	ft
1	<15
2	15-21
3	>21-27
4	>27-33
5	>33-39
6	>39-45
7	>45


552
554
556


SCALE
1 0 1 MILE
1000 0 1000 2000 METERS
1000 0 1000 2000 YARDS

4
7
7
7
2
3
2
7
7
2
3
7
7
7
7
4
7

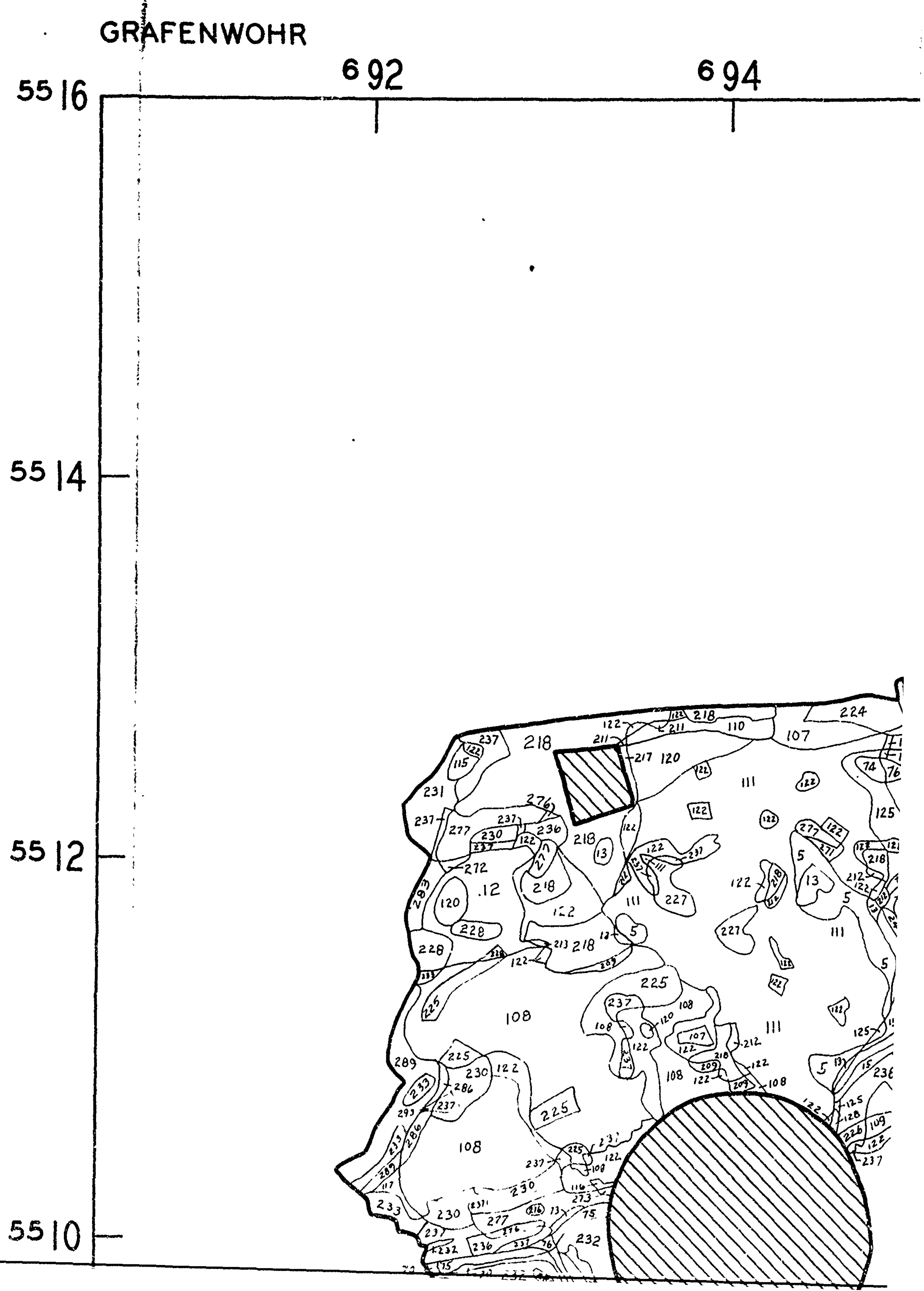
TERRAIN FACTOR COMPLEX MAP
WEST GERMANY

AREAL FACTOR COMPLEXES
BERGEN-HOHNE

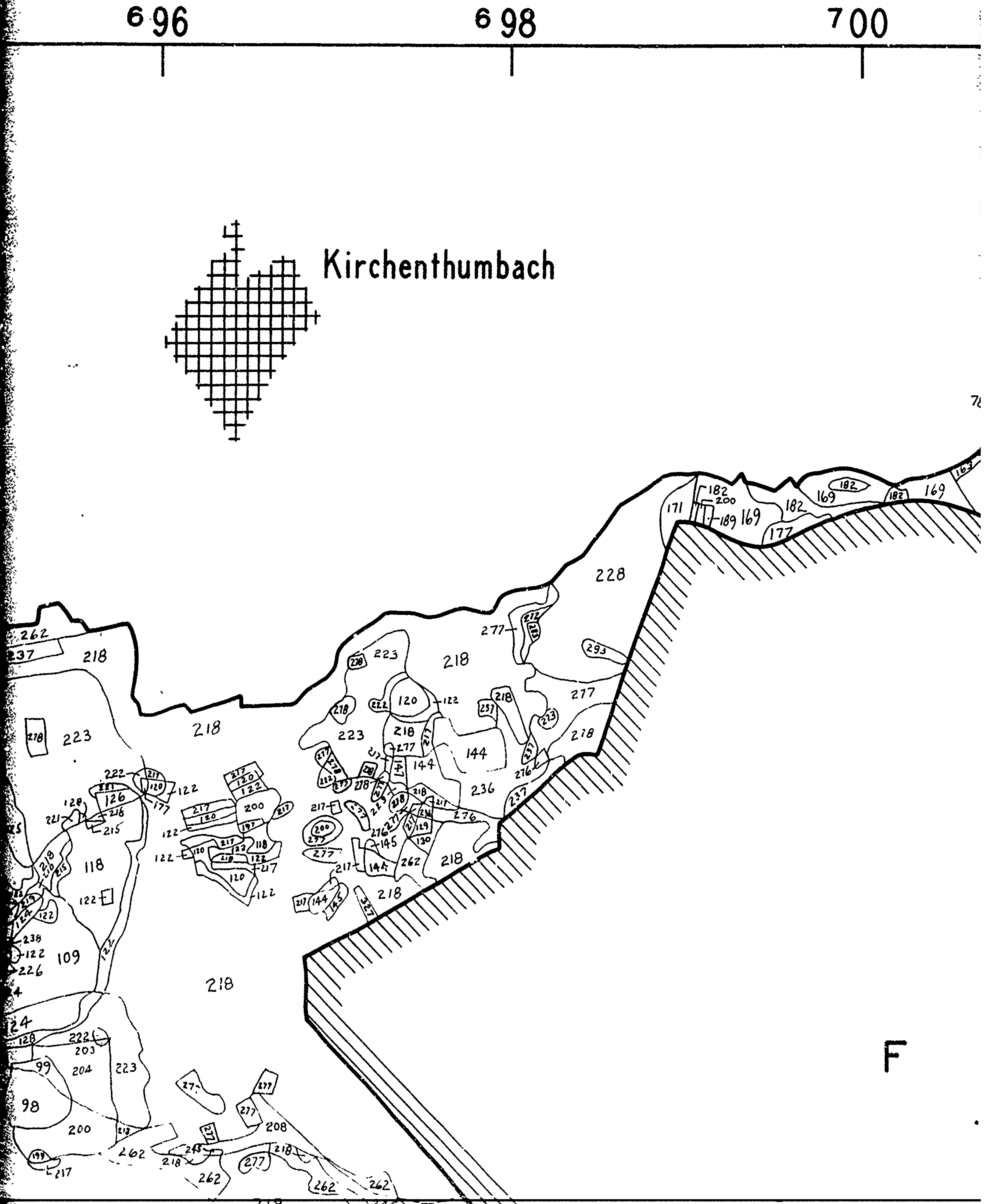
26

PLATE 2

GRAFENWOHR


GRAFENWOHR
692
694
5516
5514
5512
5510

2



702
704
706
164
79
78
174
230
80
230
78
182
79
82
180
182
13
7
182
181
97
304
122
277
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300
324
155
324
154
274
158
108
325
327
52
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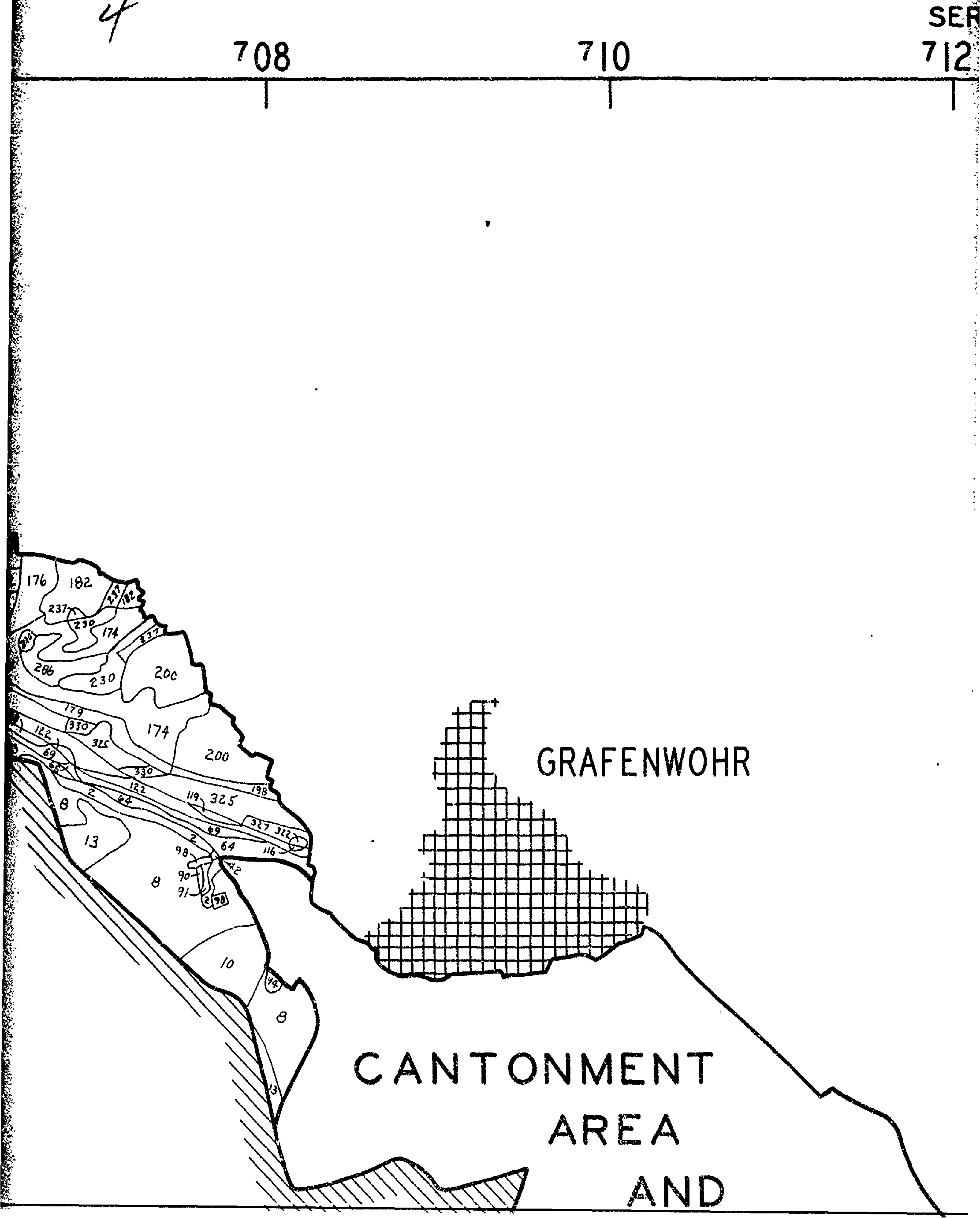
122
107
121
122
120
103
57
41
56
104
105
322
311
232
237
116
224
224
13
122
121
122
78
120
69
182
65
RING RANGE

4



IES M841-TR-Z 62

7|4 55|6

55|4

55|2

55|0

Map Unit	SURFACE GEOMETRY					SURFACE COMPOSITION	Sp Sp	
	SL	OS	EA	IA	SH		1.0	2.5
1	1	1	1/1	10/10	1/1	6M	2	2
2	2	1	1/1	10/10	1/1	6M	3	3
3	1	1	1/1	10/10	1/1	7	1	2
4	1	1	1/1	10/10	1/1	7	2	2
5	1	1	1/1	10/10	1/1	7	2	2
6	1	1	1/1	10/10	1/1	7	2	2
7	1	1	1/1	10/10	1/1	7	2	2
8	1	1	1/1	10/10	1/1	7	3	3
9	1	1	1/1	10/10	1/1	7	3	3
10	1	1	1/1	10/10	1/1	7	3	3
11	1	1	1/1	10/10	1/1	7	4	4
12	1	1	1/1	10/10	1/1	7	6	6
13	1	1	1/1	10/10	1/1	7	7	7
14	1	1	1/1	10/10	1/1	7S	2	2
15	1	1	1/1	10/10	1/1	7S	2	2
16	1	1	1/1	10/10	1/1	7S	7	7
17	1	1	2/2	10/10	2/2	1	7	7
18	1	1	2/2	10/10	2/2	1	7	7
19	1	1	2/2	10/10	2/2	2M	7	7
20	1	1	2/2	10/10	2/2	3M	2	2
21	1	1	2/2	10/10	2/2	3M	2	2
22	1	1	2/2	10/10	2/2	3M	3	3
23	1	1	2/2	10/10	2/2	3M	3	3
24	1	1	2/2	10/10	2/2	3M	7	7
25	1	1	2/2	10/10	2/2	5M	2	2
26	1	1	2/2	10/10	2/2	5M	7	7
27	1	1	2/2	10/10	2/2	5M	2	2
28	1	1	2/2	10/10	2/2	5M	3	3
29	1	1	2/2	10/10	2/2	6M	1	1
30	1	1	2/2	10/10	2/2	6M	1	1
31	1	1	2/2	10/10	2/2	6M	2	2
32	1	1	2/2	10/10	2/2	6M	2	2
33	1	1	2/2	10/10	2/2	6M	2	2
34	1	1	2/2	10/10	2/2	6M	2	2
35	1	1	2/2	10/10	2/2	6M	2	2
36	1	1	2/2	10/10	2/2	6M	3	3
37	1	1	2/2	10/10	2/2	6M	3	3
38	1	1	2/2	10/10	2/2	6M	3	3
39	1	1	2/2	10/10	2/2	6M	3	3
40	1	1	2/2	10/10	2/2	6M	6	6
41	1	1	2/2	10/10	2/2	6M	7	7
42	1	1	2/2	10/10	2/2	6M	7	7
43	1	1	2/2	10/10	2/2	7	1	1
44	1	1	2/2	10/10	2/2	7	1	1
45	1	1	2/2	10/10	2/2	7	2	2
46	1	1	2/2	10/10	2/2	7	2	2
47	1	1	2/2	10/10	2/2	7	2	2
48	1	1	2/2	10/10	2/2	7	2	2
49	1	1	2/2	10/10	2/2	7	2	2
50	1	1	2/2	10/10	2/2	7	2	2
51	1	1	2/2	10/10	2/2	7	3	3
52	1	1	2/2	10/10	2/2	7	3	3
53	1	1	2/2	10/10	2/2	7	3	[illegible]

LEGEND

VEGETATION						
Spacing of Stems > the Specified Diameter, in.						Visibility
.5	4.0	5.5	7.0	8.5	10.0	
2	2	2	3	3	4	7
3	3	3	3	4	5	7
2	4	5	5	6	7	2
2	2	2	3	3	4	7
2	2	2	3	4	4	7
2	2	2	3	4	5	7
2	2	2	4	6	7	7
3	3	3	3	4	5	7
3	3	3	4	4	4	7
3	4	4	4	5	5	4
4	4	4	4	5	5	7
6	6	6	6	6	7	7
7	7	7	7	7	7	7
2	2	2	2	4	6	7
2	2	2	3	4	4	7
7	7	7	7	7	7	7
7	7	7	7	7	7	1
7	7	7	7	7	7	7
7	7	7	7	7	7	7
2	2	2	3	6	7	7
2	2	2	4	7	7	7
3	3	3	3	3	4	7
3	3	3	3	4	5	7
7	7	7	7	7	7	7
2	2	2	4	7	7	7
7	7	7	7	7	7	7
2	2	2	4	7	7	7
3	3	3	3	4	5	7
1	2	2	2	3	4	7
1	2	4	7	7	7	7
2	2	2	2	2	3	7
2	2	2	3	3	4	7
2	2	2	3	4	4	7
2	2	2	3	6	7	7
2	2	2	4	7	7	7
3	3	3	3	3	4	7
3	3	3	3	4	5	7
3	3	3	4	4	4	7
3	4	4	4	5	5	4
6	6	6	6	6	7	7
7	7	7	7	7	7	1
7	7	7	7	7	7	7
1	2	2	2	3	4	7
1	2	4	7	7	7	7
2	2	2	2	2	3	7
2	2	2	2	3	4	7
2	2	2	3	3	4	7
2	2	2	3	4	4	7
2	2	2	3	4	5	7
2	2	2	4	7	7	7
3	3	3	3	4	5	7
3	3	3	4	4	4	7
3	4	4	4	5	5	4

Map Unit	SURFACE GEOMETRY					SURFACE COMPOSITION	V			
							Spacing of S Specified Di			
	SL	OS	EA	IA	SH		1.0	2.5	4.0	5.5
73	1	1	5/6	10/10	4/4	7	7	7	7	7
74	1	1	5/6	10/10	4/4	7S	2	2	2	2
75	1	1	5/6	10/10	4/4	7S	3	3	3	3
76	1	1	5/6	10/10	4/4	7S	7	7	7	7
77	1	1	10/10	10/10	1/1	6M	2	2	2	2
78	1	1	10/10	10/10	1/1	6M	6	6	6	6
79	1	1	10/10	10/10	1/1	6M	7	7	7	7
80	1	1	10/10	10/10	1/1	7	2	2	2	2
81	1	1	10/10	10/10	1/1	7	4	4	4	4
82	1	1	10/10	10/10	1/1	7	6	6	6	6
83	1	1	10/10	10/10	1/1	7	7	7	7	7
84	1	1	10/10	10/10	1/1	7S	2	2	2	2
85	1	1	10/10	10/10	1/1	7S	7	7	7	7
86	1	2	4/3	7/10	8/7	7	2	2	2	2
87	1	2	4/3	9/10	8/7	7	4	4	4	4
88	1	2	4/3	7/10	8/7	7	6	6	6	6
89	1	2	4/3	7/10	8/7	7	7	7	7	7
90	1	3	2/2	4/4	2/2	6M	3	3	3	3
91	1	3	2/2	4/4	2/2	6M	7	7	7	7
92	1	3	2/2	4/4	2/2	7	1	1	1	2
93	1	3	2/2	4/4	2/2	7	2	2	2	2
94	1	3	2/2	4/4	2/2	7	3	3	3	3
95	1	3	2/2	4/4	2/2	7	3	3	4	4
96	1	3	2/2	4/4	2/2	7	6	6	6	6
97	1	3	2/2	4/4	2/2	7	7	7	7	7
98	1	3	2/2	4/4	2/2	7	7	7	7	7
99	1	3	2/2	4/4	2/2	7S	7	7	7	7
100	2	1	1/1	10/10	1/1	2M	7	7	7	7
101	2	1	1/1	10/10	1/1	6M	1	2	4	5
102	2	1	1/1	10/10	1/1	6M	3	3	3	3
103	2	1	1/1	10/10	1/1	6M	6	6	6	6
104	2	1	1/1	10/10	1/1	6M	7	7	7	7
105	2	1	1/1	10/10	1/1	6M	7	7	7	7
106	2	1	1/1	10/10	1/1	7	1	2	4	5
107	2	1	1/1	10/10	1/1	7	2	2	2	2
108	2	1	1/1	10/10	1/1	7	2	2	2	2
109	2	1	1/1	10/10	1/1	7	2	2	2	2
110	2	1	1/1	10/10	1/1	7	2	2	2	2
111	2	1	1/1	10/10	1/1	7	2	2	2	2
112	2	1	1/1	10/10	1/1	7	2	2	2	2
113	2	1	1/1	10/10	1/1	7	2	2	2	
114	2	1	1/1	10/10	1/1	7	2	2	2	
115	2	1	1/1	10/10	1/1	7	3	3	3	
116	2	1	1/1	10/10	1/1	7	3	3	3	
118	2	1	1/1	10/10	1/1	7	3	3	4	
119	2	1	1/1	10/10	1/1	7	4	4	4	
120	2	1	1/1	10/10	1/1	7	6	6	6	
121	2	1	1/1	10/10	1/1	7	7	7	7	
122	2	1	1/1	10/10	1/1	7	7	7	7	
123	2	1	1/1	10/10	1/1	7S	1	1	2	
124	2	1	1/1	10/10	1/1	7S	2	2	2	
125	2	1	1/1	10/10	1/1	7S	2	2	2	
126	2	1	1/1	10/10	1/1	7S	3	3	4	
127	2	1	1/1	10/10	1/1	7S	6	6	6	

...TATION ...s > the ...ter, in. 8.5	10.0	Visibility
7	7	7
4	4	7
4	5	7
7	7	7
7	7	7
6	7	7
7	7	7
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2	7	7
3	4	7
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3	4	7
4	4	7
4	5	7
6	7	7
7	7	7
3	4	7
4	5	7
5	5	4
5	5	7
6	7	7
7	7	1
7	7	7
3	4	7
4	6	7
4	4	7
5	5	4

Map Unit	SURFACE GEOMETRY SL	OS	EA	IA	SH	SURFACE COMPOSITION	VEGETATION Spacing of Stems > the Specified Diameter, in. 1.0	2.5	4.0	5.5	7.0	8.5	10.0
145	2	1	2/2	10/10	3/3	7	7	7	7	7	7	7	7
146	2	1	2/2	10/10	3/3	7S	2	2	2	2	3	4	5
147	2	1	2/2	10/10	3/3	7S	6	6	6	6	6	6	7
148	2	1	2/2	10/10	3/3	7S	7	7	7	7	7	7	7
149	2	1	2/5	3/7	1/1	6M	1	1	2	4	7	7	7
150	2	1	2/5	3/7	1/1	6M	7	7	7	7	7	7	7
151	2	1	2/5	3/7	1/1	7	2	2	2	2	3	4	5
152	2	1	2/5	5/7	1/1	7	2	2	2	2	4	7	7
153	2	1	2/5	3/7	1/1	7	3	3	3	3	3	4	5
154	2	1	2/5	3/7	1/1	7	3	3	3	3	4	4	4
155	2	1	2/5	3/7	1/1	7	3	3	4	4	4	5	5
156	2	1	2/5	3/7	1/1	7	4	4	4	4	4	5	5
157	2	1	2/5	3/7	1/1	7	6	6	6	6	6	6	7
158	2	1	2/5	3/7	1/1	7	7	7	7	7	7	7	7
159	2	1	2/5	3/7	1/1	7S	6	6	6	6	6	6	7
160	2	1	2/5	3/7	1/1	7S	7	7	7	7	7	7	7
161	2	1	3/2	10/10	2/2	6M	2	2	2	2	2	3	4
162	2	1	3/2	10/10	2/2	6M	2	2	2	2	3	4	4
163	2	1	3/2	10/10	2/2	6M	2	2	2	2	4	7	7
164	2	1	3/2	10/10	2/2	6M	6	6	6	6	6	6	7
165	2	1	3/2	10/10	2/2	6M	7	7	7	7	7	7	7
166	2	1	3/2	10/10	2/2	7	1	1	1	2	2	4	7
167	2	1	3/2	10/10	2/2	7	1	1	2	2	2	3	4
168	2	1	3/2	10/10	2/2	7	2	2	2	2	2	2	3
169	2	1	3/2	10/10	2/2	7	2	2	2	2	2	3	4
170	2	1	3/2	10/10	2/2	7	2	2	2	2	3	4	4
171	2	1	3/2	10/10	2/2	7	2	2	2	2	2	4	5
172	2	1	3/2	10/10	2/2	7	2	2	2	2	3	6	7
173	2	1	3/2	10/10	2/2	7	2	2	2	2	4	6	7
174	2	1	3/2	10/10	2/2	7	2	2	2	2	4	7	7
175	2	1	3/2	10/10	2/2	7	3	3	3	3	3	3	4
176	2	1	3/2	10/10	2/2	7	3	3	3	3	3	4	5
177	2	1	3/2	10/10	2/2	7	3	3	3	3	4	4	4
178	2	1	3/2	10/10	2/2	7	3	3	4	4	4	5	5
179	2	1	3/2	10/10	2/2	7	4	4	4	4	4	5	5
180	2	1	3/2	10/10	2/2	7	6	6	6	6	6	6	7
181	2	1	3/2	10/10	2/2	7	7	7	7	7	7	7	7
182	2	1	3/2	10/10	2/2	7	7	7	7	7	7	7	7
183	2	1	3/2	10/10	2/2	7S	3	3	4	4	4	5	5
184	2	1	3/2	10/10	3/2	7S	6	6	6	6	6	6	7
185	2	1	3/2	10/10	2/2	7S	7	7	7	7	7	7	7
186	2	1	3/3	10/10	2/2	6M	2	2	2	2	3	4	4
187	2	1	3/3	10/10	2/2	6M	3	3	3	3	4	4	4
188	2	1	3/3	10/10	2/2	7	2	2	2	2	2	2	3
189	2	1	3/3	10/10	3/2	7	2	2	2	2	2	3	4
190	2	1	3/3	10/10	2/2	7	2	2	2	2	3	4	4
191	2	1	3/3	10/10	2/2	7	2	2	2	2	3	4	5
192	2	1	3/3	10/10	2/2	7	2	2	2	2	3	6	7
193	2	1	3/3	10/10	2/2	7	2	2	2	2	4	6	7
194	2	1	3/3	10/10	2/2	7	3	3	3	3	3	3	4
195	2	1	3/3	10/10	2/2	7	3	3	3	3	3	4	5
196	2	1	3/3	10/10	2/2	7	3	3	3	3	4	4	4
197	2	1	3/3	10/10	2/2	7	3	3	4	4	4	5	5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	4	4	4	4	4	5	5

8

METRY		SURFACE COMPOSITION	VEGETATION							
			Spacing of Stems > the Specified Diameter, in.							Visibility
IA	SH		1.0	2.5	4.0	5.5	7.0	8.5	10.0	
10/10	3/3	7	7	7	7	7	7	7	7	7
10/10	3/3	7S	2	2	2	2	3	4	5	7
10/10	3/3	7S	6	6	6	6	6	6	7	7
10/10	3/3	7S	7	7	7	7	7	7	7	7
3/7	1/1	6M	1	1	2	4	7	7	7	7
3/7	1/1	6M	7	7	7	7	7	7	7	7
3/7	1/1	7	2	2	2	2	3	4	5	7
5/7	1/1	7	2	2	2	2	4	7	7	7
3/7	1/1	7	3	3	3	3	3	4	5	7
3/7	1/1	7	3	3	3	3	4	4	4	7
3/7	1/1	7	3	3	4	4	4	5	5	4
3/7	1/1	7	4	4	4	4	4	5	5	7
3/7	1/1	7	6	6	6	6	6	6	7	7
3/7	1/1	7	7	7	7	7	7	7	7	7
3/7	1/1	7S	6	6	6	6	6	6	7	7
3/7	1/1	7S	7	7	7	7	7	7	7	7
10/10	2/2	6M	2	2	2	2	2	3	4	7
10/10	2/2	6M	2	2	2	2	3	4	4	7
10/10	2/2	6M	2	2	2	2	4	7	7	7
10/10	2/2	6M	6	6	6	6	6	6	7	7
10/10	2/2	6M	7	7	7	7	7	7	7	7
10/10	2/2	7	1	1	1	2	2	4	7	4
10/10	2/2	7	1	1	2	2	2	3	4	7
10/10	2/2	7	2	2	2	2	2	2	3	7
10/10	2/2	7	2	2	2	2	2	3	4	7
10/10	2/2	7	2	2	2	2	3	4	4	7
10/10	2/2	7	2	2	2	2	2	4	5	7
10/10	2/2	7	2	2	2	2	3	6	7	7
10/10	2/2	7	2	2	2	2	4	6	7	7
10/10	2/2	7	2	2	2	2	4	7	7	7
10/10	2/2	7	3	3	3	3	3	3	4	7
10/10	2/2	7	3	3	3	3	3	4	5	7
10/10	2/2	7	3	3	3	3	4	4	4	7
10/10	2/2	7	3	3	4	4	4	5	5	4
10/10	2/2	7	4	4	4	4	4	5	5	7
10/10	2/2	7	6	6	6	6	6	6	7	7
10/10	2/2	7	7	7	7	7	7	7	7	1
10/10	2/2	7	7	7	7	7	7	7	7	7
10/10	2/2	7S	3	3	4	4	4	5	5	4
10/10	3/2	7S	6	6	6	6	6	6	7	7
10/10	2/2	7S	7	7	7	7	7	7	7	7
10/10	2/2	6M	2	2	2	2	3	4	4	7
10/10	2/2	6M	3	3	3	3	4	4	4	7
10/10	2/2	7	2	2	2	2	2	2	3	7
10/10	3/2	7	2	2	2	2	2	3	4	7
10/10	2/2	7	2	2	2	2	3	4	4	7
10/10	2/2	7	2	2	2	2	3	4	5	7
10/10	2/2	7	2	2	2	2	3	6	7	7
10/10	2/2	7	2	2	2	2	4	6	7	7
10/10	2/2	7	3	3	3	3	3	3	4	7
10/10	2/2	7	3	3	3	3	3	4	5	7
10/10	2/2	7	3	3	3	3	4	4	4	7
10/10	2/2	7	3	3	4	4	4	5	5	4
[illegible]	2/2	[illegible]	4	4	4	4	4	5	5	7

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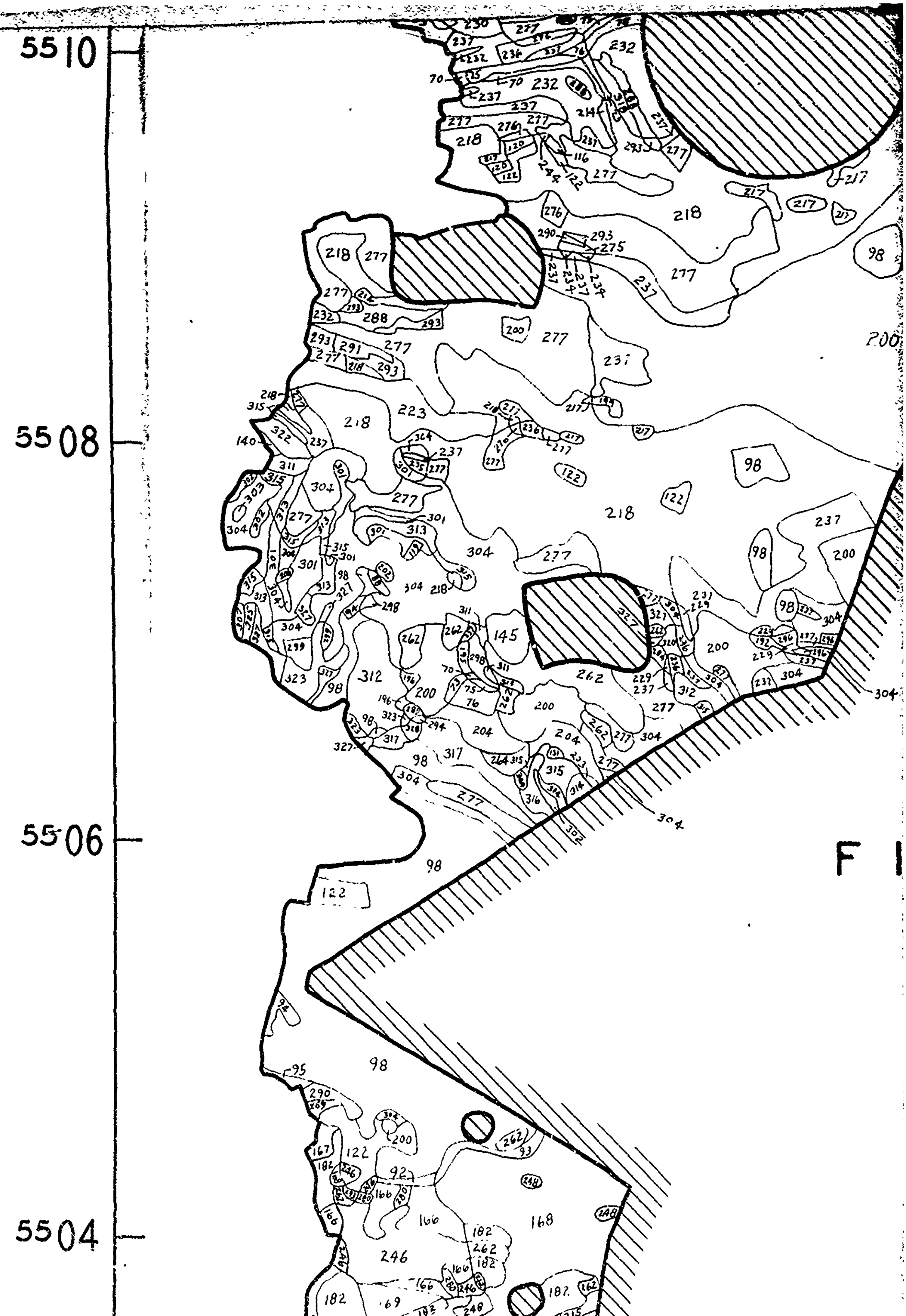

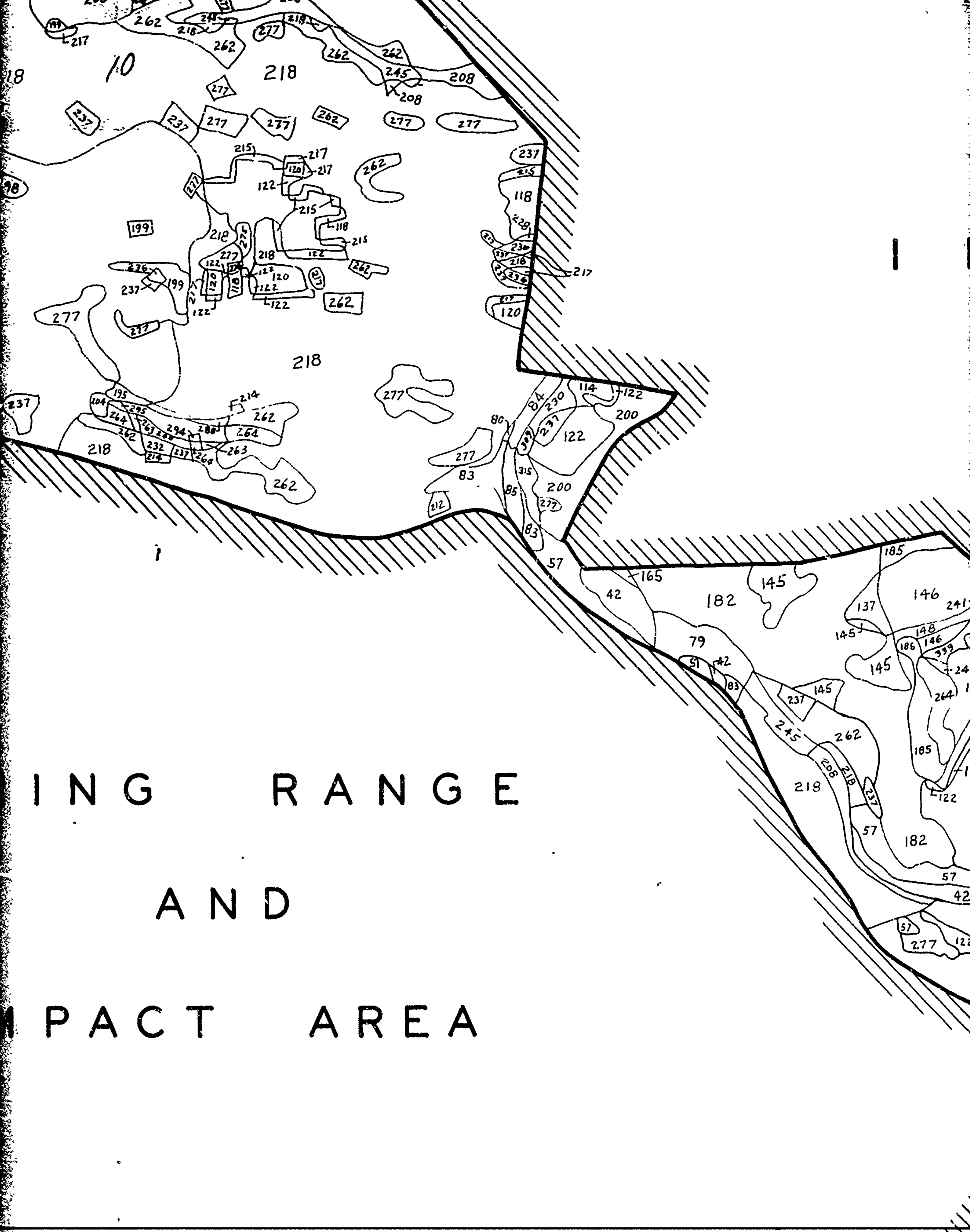

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AND

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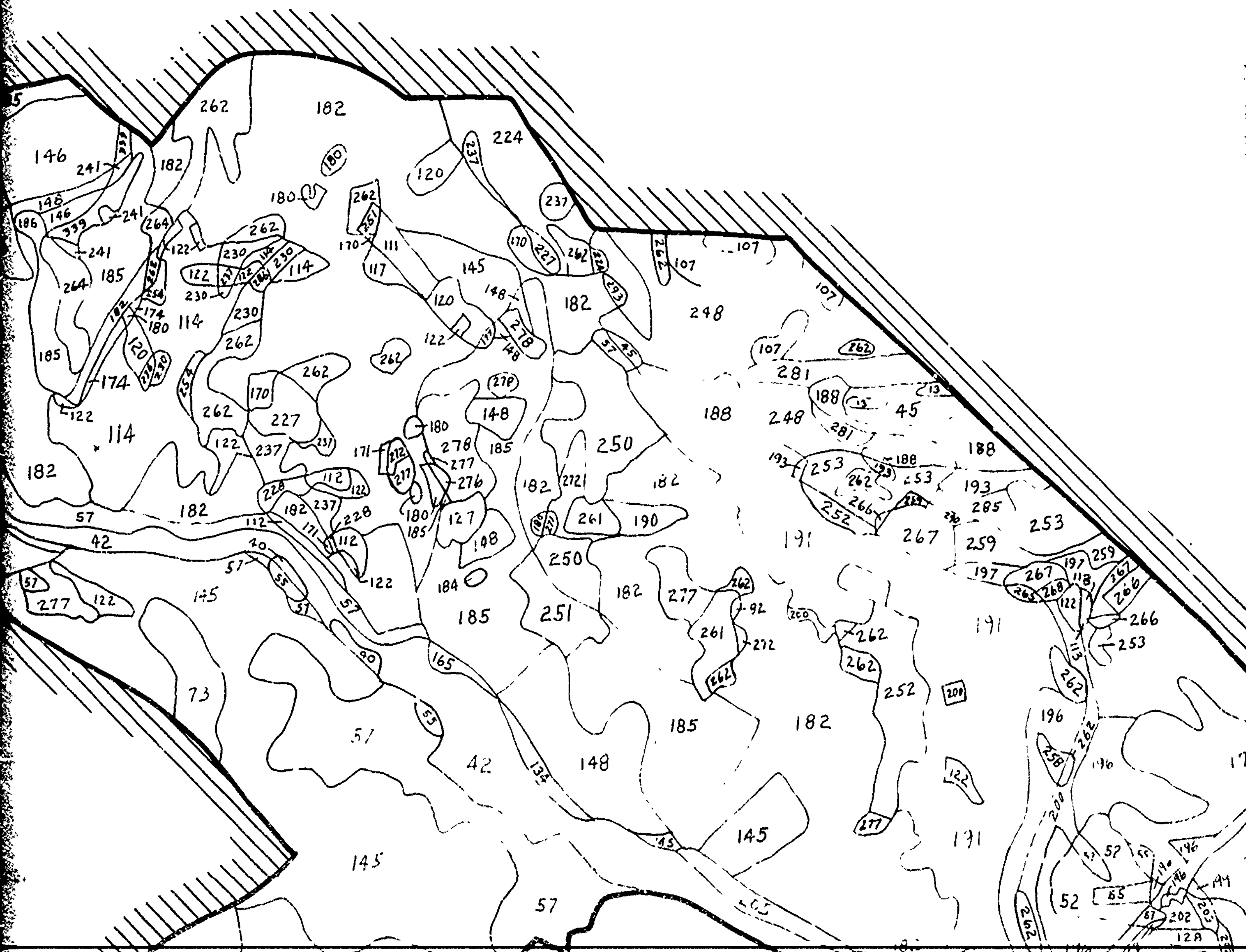
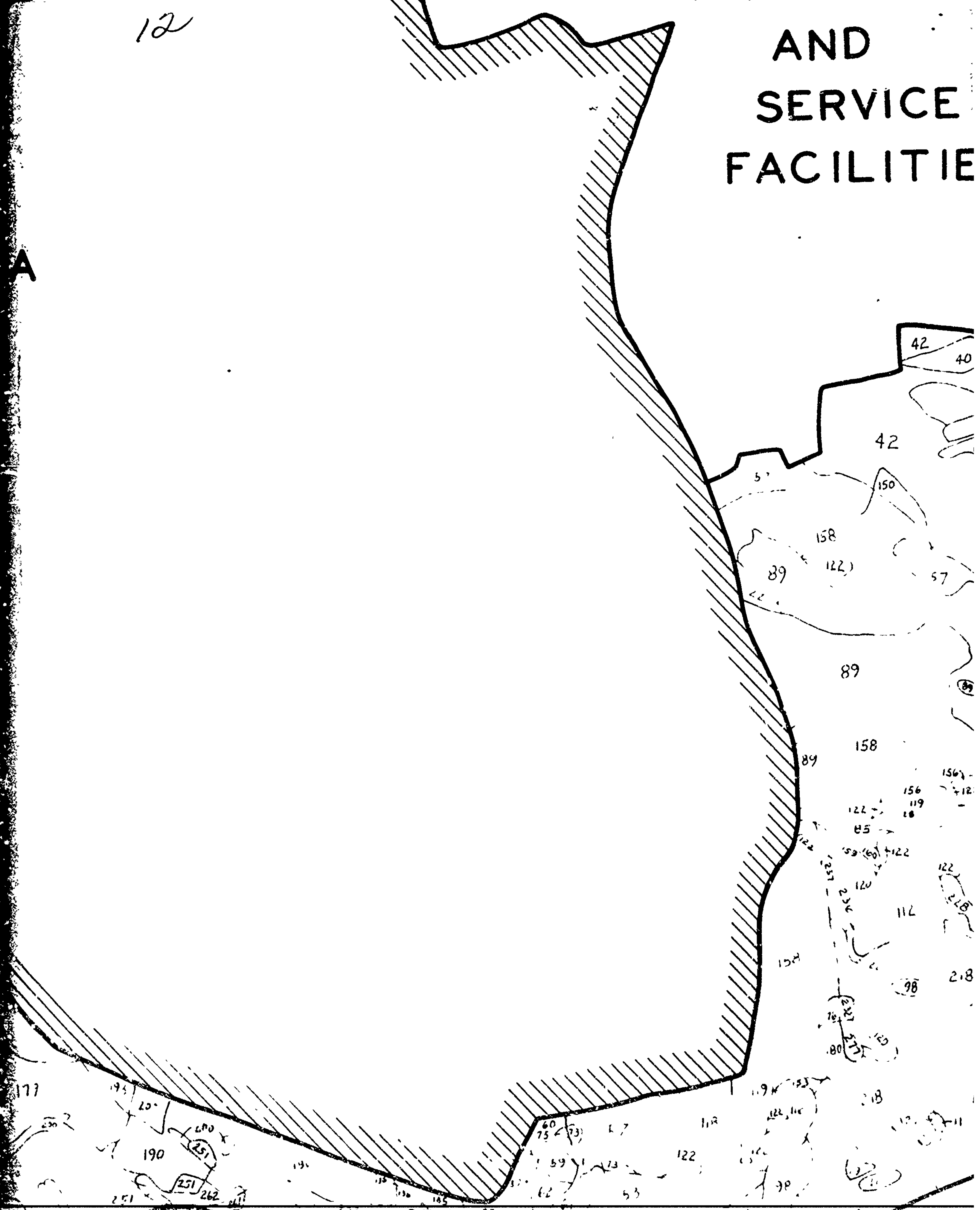


12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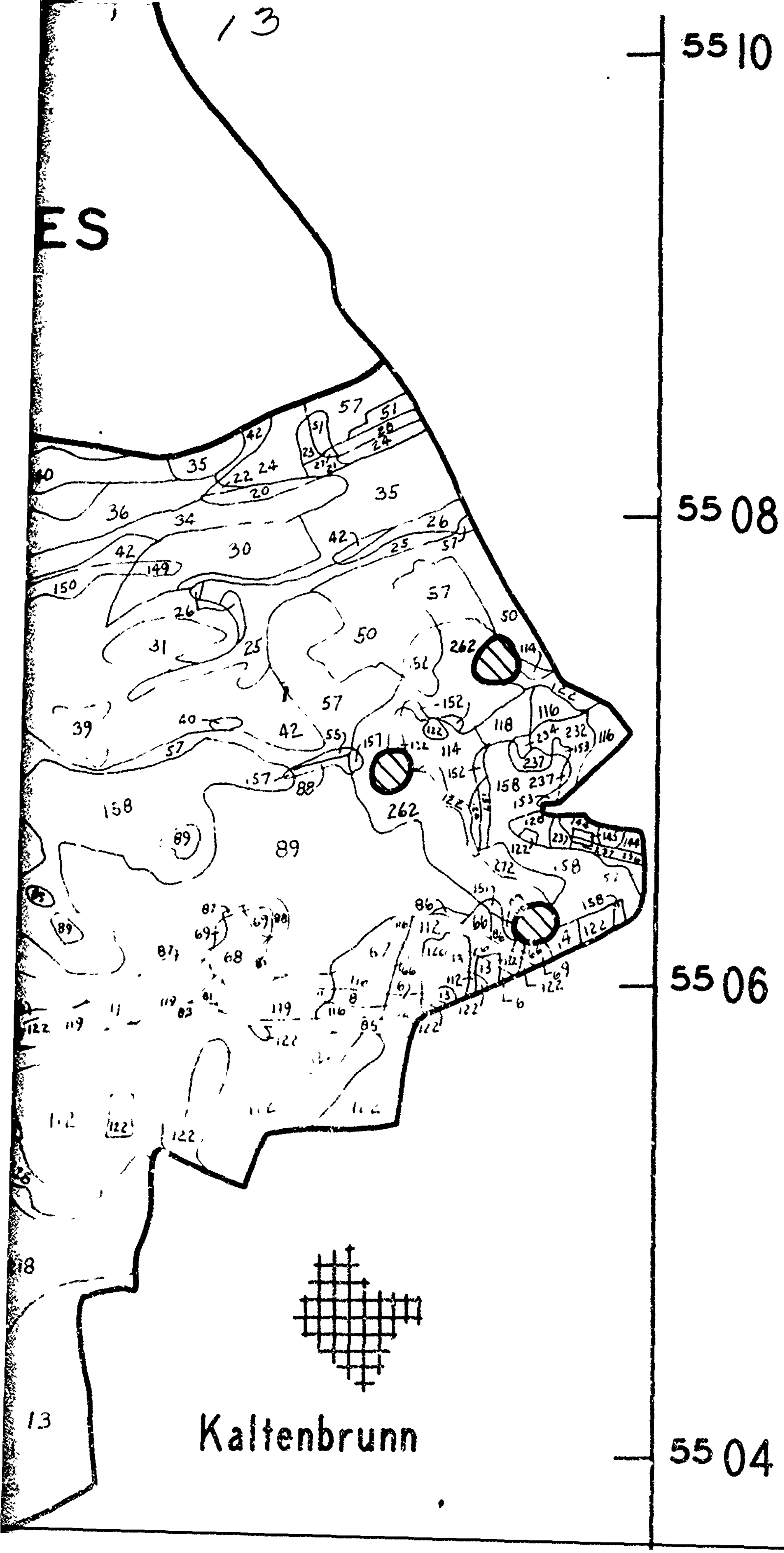

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51	1	1	2/2	10/10	2/2
52	1	1	2/2	10/10	2/2
53	1	1	2/2	10/10	2/2
54	1	1	2/2	10/10	2/2
55	1	1	2/2	10/10	2/2
56	1	1	2/2	10/10	2/2
57	1	1	2/2	10/10	2/2
58	1	1	2/2	10/10	2/2
59	1	1	2/2	10/10	2/2
60	1	1	2/2	10/10	2/2
61	1	1	2/2	10/10	2/2
62	1	1	2/2	10/10	2/2
63	1	1	3/8	10/7	1/1
64	1	1	3/8	10/7	1/1
65	1	1	3/8	10/7	1/1
66	1	1	3/8	10/7	1/1
67	1	1	3/8	10/7	1/1
68	1	1	3/8	10/7	1/1
69	1	1	3/8	10/7	1/1
70	1	1	5/6	10/10	4/4
71	1	1	5/6	10/10	4/4
72	1	1	5/6	10/10	4/4

Map Unit	SURFACE GEOMETRY				
	SL	OS	EA	IA	SH
218	2	3	2/2	4/4	2/2
219	2	3	2/2	4/4	2/2
220	2	3	2/2	4/4	2/2
221	2	3	2/2	4/4	2/2
222	2	3	2/2	4/4	2/2
223	2	3	2/2	4/4	2/2
224	3	1	1/1	10/10	2/2
225	3	1	1/1	10/10	2/2
226	3	1	1/1	10/10	2/2
227	3	1	1/1	10/10	2/2
228	3	1	1/1	10/10	2/2
229	3	1	1/1	10/10	2/2
230	3	1	1/1	10/10	2/2
231	3	1	1/1	10/10	2/2
232	3	1	1/1	10/10	2/2
233	3	1	1/1	10/10	2/2
234	3	1	1/1	10/10	2/2
235	3	1	1/1	10/10	2/2
236	3	1	1/1	10/10	2/2
237	3	1	1/1	10/10	2/2
238	3	1	1/1	10/10	2/2
239	3	1	1/1	10/10	2/2
240	3	1	1/1	10/10	2/2
241	3	1	1/1	10/10	2/2
242	3	1	2/2	10/10	3/3
243	3	1	2/2	10/10	3/3
244	3	1	2/2	10/10	3/3
245	3	1	2/2	10/10	3/3
246	3	1	2/2	10/10	3/3
247	3	1	2/2	10/10	3/3
248	3	1	2/2	10/10	3/3

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7	7	7	7	7	7	7	1
7	7	7	7	7	7	7	7
1	1	2	2	2	3	4	7
2	2	2	2	3	4	4	7
3	3	3	3	3	4	5	7
3	3	4	4	4	5	5	4
6	6	6	6	6	6	7	7
3	3	3	3	3	4	5	7
4	4	4	4	4	5	5	7
7	7	7	7	7	7	7	7
2	2	2	2	3	4	5	7
3	3	3	3	3	4	5	7
4	4	4	4	4	5	5	7
7	7	7	7	7	7	7	7
3	3	3	3	3	4	5	7
4	4	4	4	4	5	5	7
6	6	6	6	6	6	7	7

124	2	1	1/1	10/10	1/1	7S	2	2
125	2	1	1/1	10/10	1/1	7S	2	2
126	2	1	1/1	10/10	1/1	7S	3	3
127	2	1	1/1	10/10	1/1	7S	6	6
128	2	1	1/1	10/10	1/1	7S	7	7
129	2	1	1/3	4/7	5/7	7	6	6
130	2	1	1/3	4/7	5/7	7	7	7
131	2	1	1/3	4/7	5/7	7S	7	7
132	2	1	2/2	10/10	3/3	2M	3	3
133	2	1	2/2	10/10	3/3	6M	2	2
134	2	1	2/2	10/10	3/3	6M	7	7
135	2	1	2/2	10/10	3/3	7	2	2
136	2	1	2/2	10/10	3/3	7	2	2
137	2	1	2/2	10/10	3/3	7	2	2
138	2	1	2/2	10/10	3/3	7	3	3
139	2	1	2/2	10/10	3/3	7	3	3
140	2	1	2/2	10/10	3/3	7	3	3
141	2	1	2/2	10/10	3/3	7	3	3
142	2	1	2/2	10/10	3/3	7	3	3
143	2	1	2/2	10/10	3/3	7	4	4
144	2	1	2/2	10/10	3/3	7	6	6

VEGETATION							
Spacing of Stems > the Specified Diameter, in.							
1.0	2.5	4.0	5.5	7.0	8.5	10.0	Visibility
7	7	7	7	7	7	7	7
2	2	2	2	2	4	6	7
2	2	2	2	3	4	4	7
3	3	4	4	4	5	5	4
6	6	6	6	6	6	7	7
7	7	7	7	7	7	7	7
2	2	2	2	2	2	3	7
2	2	2	2	2	3	4	7
2	2	2	2	2	4	6	7
2	2	2	2	3	4	4	7
2	2	2	2	3	4	5	7
2	2	2	2	3	6	7	7
2	2	2	2	3	7	7	7
3	3	3	3	3	3	4	7
3	3	3	3	3	4	5	7
3	3	3	3	4	4	4	7
3	3	4	4	4	5	5	4
4	4	4	4	4	5	5	7
6	6	6	6	6	6	7	7
7	7	7	7	7	7	7	7
2	2	2	2	2	4	6	7
2	2	2	2	3	4	5	7
3	3	3	3	3	4	5	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
2	2	2	2	2	3	4	7
2	2	2	2	3	4	4	7
7	7	7	7	7	7	7	7
1	1	1	22	2	4	7	4
1	1	2	4	7	7	7	7
1	1	2	4	7	7	7	7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Map Unit	SURFACE GEOMETRY				SURFACE COMPOSITION	Spa… Spe…	
	SL	OS	EA	IA	SH		1.0	2.5
291	4	1	1/1	10/10	2/2	7	4	4
292	4	1	1/1	10/10	2/2	7	6	6
293	4	1	1/1	10/10	2/2	7	7	7
294	4	1	1/1	10/10	2/2	7S	3	3
295	4	1	1/1	10/10	2/2	7S	7	7
296	4	1	1/1	10/10	4/4	7	2	2
297	4	1	1/1	10/10	4/4	7	3	3
298	4	1	1/1	10/10	4/4	7	3	3
299	4	1	1/1	10/10	4/4	7	3	3
300	4	1	1/1	10/10	4/4	7	3	3
301	4	1	1/1	10/10	4/4	7	4	4
302	4	1	1/1	10/10	4/4	7	6	6
303	4	1	1/1	10/10	4/4	7	7	7
304	4	1	1/1	10/10	4/4	7	7	7
305	5	1	3/3	7/7	7/7	7	1	1
306	5	1	3/3	7/7	7/7	7	2	2
307	5	1	3/3	7/7	7/7	7	2	2
308	5	1	3/3	7/7	7/7	7	2	2
309	5	1	3/3	7/7	7/7	7	2	2
310	5	1	3/3	7/7	7/7	7	3	3
311	5	1	3/3	7/7	7/7	7	3	3
312	5	1	3/3	7/7	7/7	7	3	3
313	5	1	3/3	7/7	7/7	7	4	4
314	5	1	3/3	7/7	7/7	7	6	6
315	5	1	3/3	7/7	7/7	7	7	7
316	5	1	3/3	7/7	7/7	7S	6	6
317	5	1	3/3	7/7	7/7	7S	7	7
318	5	3	2/2	10/10	8/8	7	3	3
319	6	1	2/2	10/10	8/8	7	2	2
320	6	1	2/2	10/10	8/8	7	22	2
321	6	1	2/2	10/10	8/8	7	3	3
322	6	1	2/2	10/10	8/8	7	3	3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	3

2	4	6	15 7
3	4	4	7
4	5	5	4
6	6	7	7
7	7	7	7
6	6	7	7
7	7	7	7
7	7	7	7
3	4	5	7
3	3	4	7
7	7	7	7
3	3	4	7
3	4	4	7
3	4	5	7
3	3	4	7
3	4	4	7
3	4	5	7
4	4	4	7
4	5	5	4
4	5	5	7
6	6	7	7

195	2	1	3/3	10/10	2/2	7	3	3	3	3	3	4	
196	2	1	3/3	10/10	2/2	7	3	3	3	3	4	4	
197	2	1	3/3	10/10	2/2	7	3	3	4	4	4	5	
198	2	1	3/3	10/10	2/2	7	4	4	4	4	4	5	
199	2	1	3/3	10/10	2/2	7	6	6	6	6	6	6	
200	2	1	3/3	10/10	2/2	7	7	7	7	7	7	7	7
201	2	1	3/3	10/10	2/2	7S	2	2	2	2	3	4	4
202	2	1	3/3	10/10	2/2	7S	3	3	3	3	4	4	4
203	2	1	3/3	10/10	2/2	7S	6	6	6	6	6	6	7
204	2	1	3/3	10/10	2/2	7S	7	7	7	7	7	7	7
205	2	2	5/10	9/5	8/7	6M	7	7	7	7	7	7	7
206	2	2	5/10	9/5	8/7	7	7	7	7	7	7	7	7
207	2	3	2/2	4/4	2/2	6M	2	2	2	2	3	3	4
208	2	3	2/2	4/4	2/2	6M	7	7	7	7	7	7	7
209	2	3	2/2	4/4	2/2	7	2	2	2	2	2	3	4
210	2	3	2/2	4/4	2/2	7	2	2	2	2	2	4	6
211	2	3	2/2	4/4	2/2	7	2	2	2	2	3	3	4
212	2	3	2/2	4/4	2/2	7	2	2	2	2	3	4	4
213	2	3	2/2	4/4	2/2	7	2	2	2	2	3	4	5
214	2	3	2/2	4/4	2/2	7	3	3	3	3	3	4	5
215	2	3	2/2	4/4	2/2	7	3	3	4	4	4	5	5
216	2	3	2/2	4/4	2/2	7	4	4	4	4	4	5	5
217	2	3	2/2	4/4	2/2	7	6	6	6	6	6	6	7

VEGETATION			
Stems > the diameter, in.			
7.0	8.5	10.0	Visibility
4	5	5	7
6	6	7	7
7	7	7	7
3	4	5	7
7	7	7	7
3	6	7	7
3	3	4	7
3	4	5	7
4	4	4	7
4	5	5	4
4	5	5	7
6	6	7	7
7	7	7	1
7	7	7	7
2	4	7	4
2	3	4	7
3	4	4	7
4	6	7	7
4	7	7	7
3	3	4	7
3	4	5	7
4	4	4	7
4	5	5	7
6	6	7	7
7	7	7	7
6	6	7	7
7	7	7	7
3	4	5	7
2	3	4	7
3	6	7	7
3	3	4	7

*Each map unit represents an array of symbols [i.e. 1,1,(1/1 10/10),2/ mapping classes of slope SL (see diagram below) obstacle spacing OS, EA and IA, and step height SH. Fractional designations indicate that were mapped. The numerator of the fraction indicates class range that countered while traversing an area in an easterly direction (i.e. azim 180 deg) and the denominator refers to a westerly direction (i.e. azim to 360 deg) assuming that the vehicle intersects the obstacle at a ri

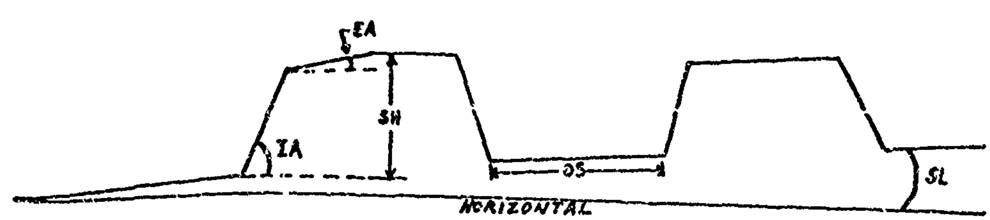
*Mapping class ranges of each surface geometry factor are:

Slope (SL)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31

Spacing (OS)	
Map Class	ft
1	0-50
2	>50-150
3	>150-225
4	>225

Approach Angle (EA-IA)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45

Step
Map Class
1
2
3
4
5
6
7
8



**Mapping class ranges for each Surface Composition unit ar

10/10	2/2	7	3	3	3	3	3	3	4	7
10/10	2/2	7	3	3	3	3	3	4	5	7
10/10	2/2	7	3	3	3	3	4	4	4	7
10/10	2/2	7	3	3	4	4	4	5	5	4
10/10	2/2	7	4	4	4	4	4	5	5	7
10/10	2/2	7	6	6	6	6	6	6	7	7
10/10	2/2	7	7	7	7	7	7	7	7	7
10/10	2/2	7S	2	2	2	2	3	4	4	7
10/10	2/2	7S	3	3	3	3	4	4	4	7
10/10	2/2	7S	6	6	6	6	6	6	7	7
10/10	2/2	7S	7	7	7	7	7	7	7	7
9/5	8/7	6M	7	7	7	7	7	7	7	7
9/5	8/7	7	7	7	7	7	7	7	7	7
4/4	2/2	6M	2	2	2	2	3	3	4	7
4/4	2/2	6M	7	7	7	7	7	7	7	7
4/4	2/2	7	2	2	2	2	2	3	4	7
4/4	2/2	7	2	2	2	2	2	4	6	7
4/4	2/2	7	2	2	2	2	3	3	4	7
4/4	2/2	7	2	2	2	2	3	4	4	7
4/4	2/2	7	2	2	2	2	3	4	5	7
4/4	2/2	7	3	3	3	3	3	4	5	7
4/4	2/2	7	3	3	4	4	4	5	5	4
4/4	2/2	7	4	4	4	4	4	5	5	7
4/4	2/2	7	6	6	6	6	6	6	7	7

represents an array of symbols [i.e. 1,1,(1/1 10/10),2/2] indicating of slope SL (see diagram below) obstacle spacing OS, approach angle step height SH. Fractional designations indicate that dual classes e numerator of the fraction indicates class range that will be en- traversing an area in an easterly direction (i.e. azimuth from >0 to e denominator refers to a westerly direction (i.e. azimuth from >180 uming that the vehicle intersect the obstacle at a right angle.

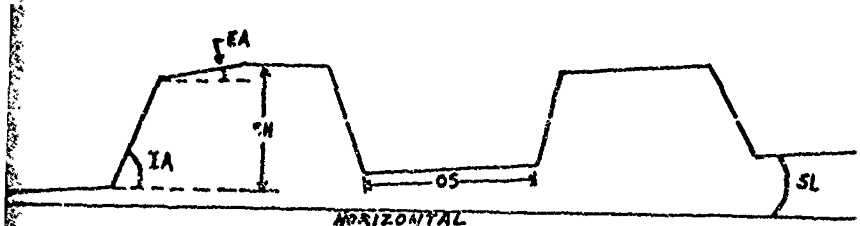
ranges of each surface geometry factor are:

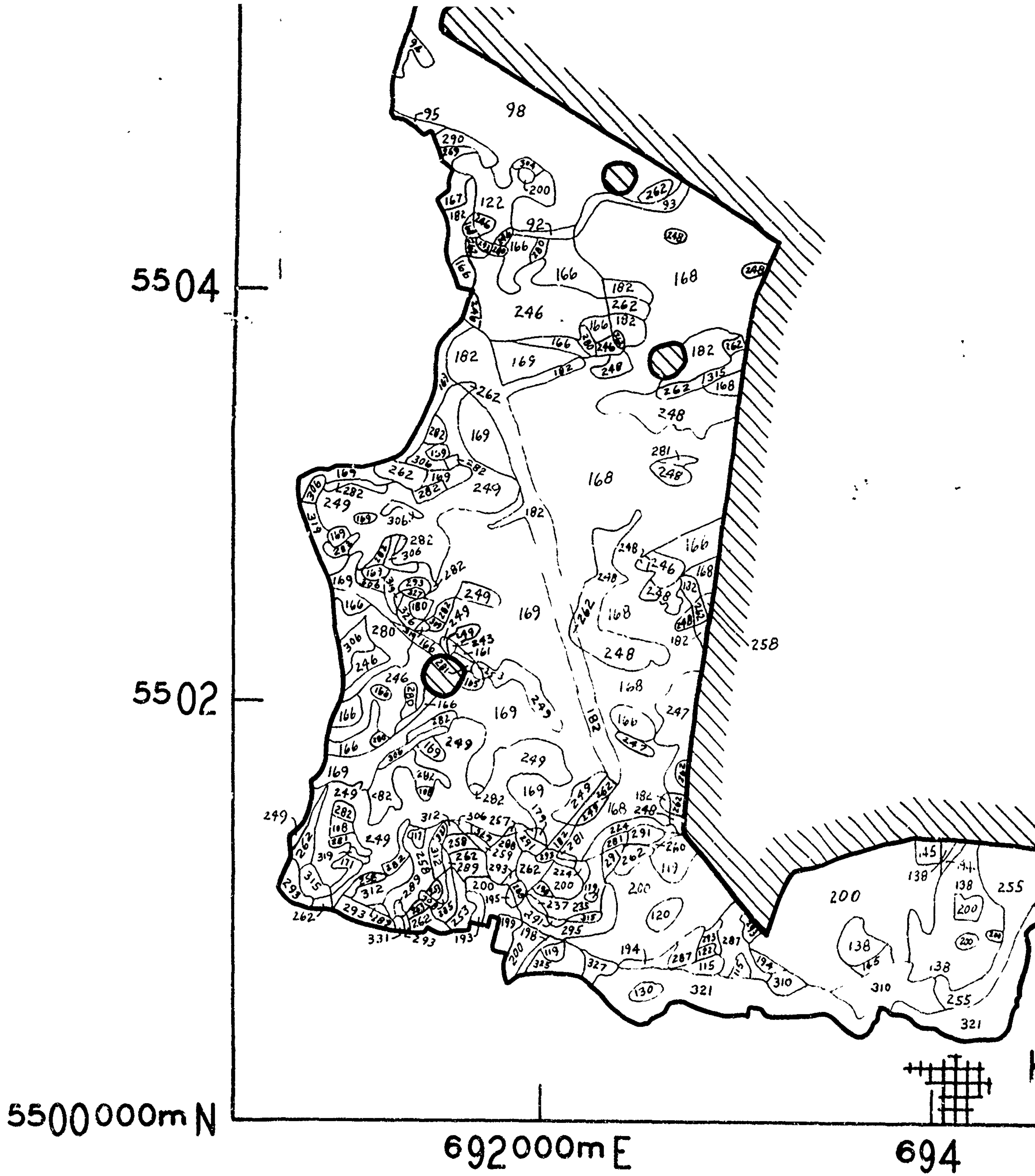
L)
eg
1.5
5-4.5
5-10
-17
-22
-27
-31

Spacing (OS)	
Map Class	ft
1	0-50
2	>50-150
3	>150-225
4	>225

Approach Angle (EA-IA)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45

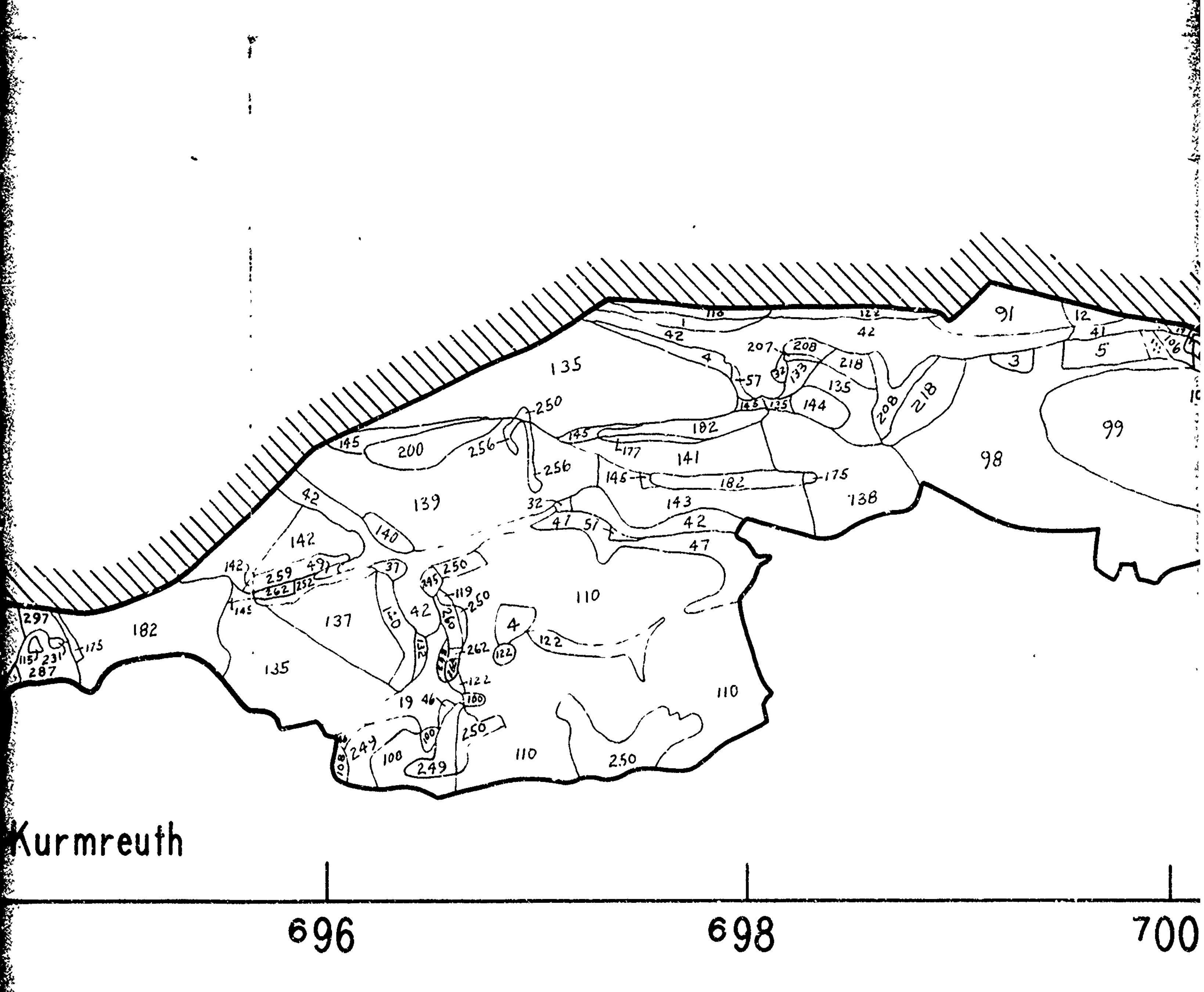
Step Height (SH)	
Map Class	in
1	<8
2	8-10
3	>10-12
4	>12-14
5	>14-16
6	>16-20
7	>20-30
8	>30

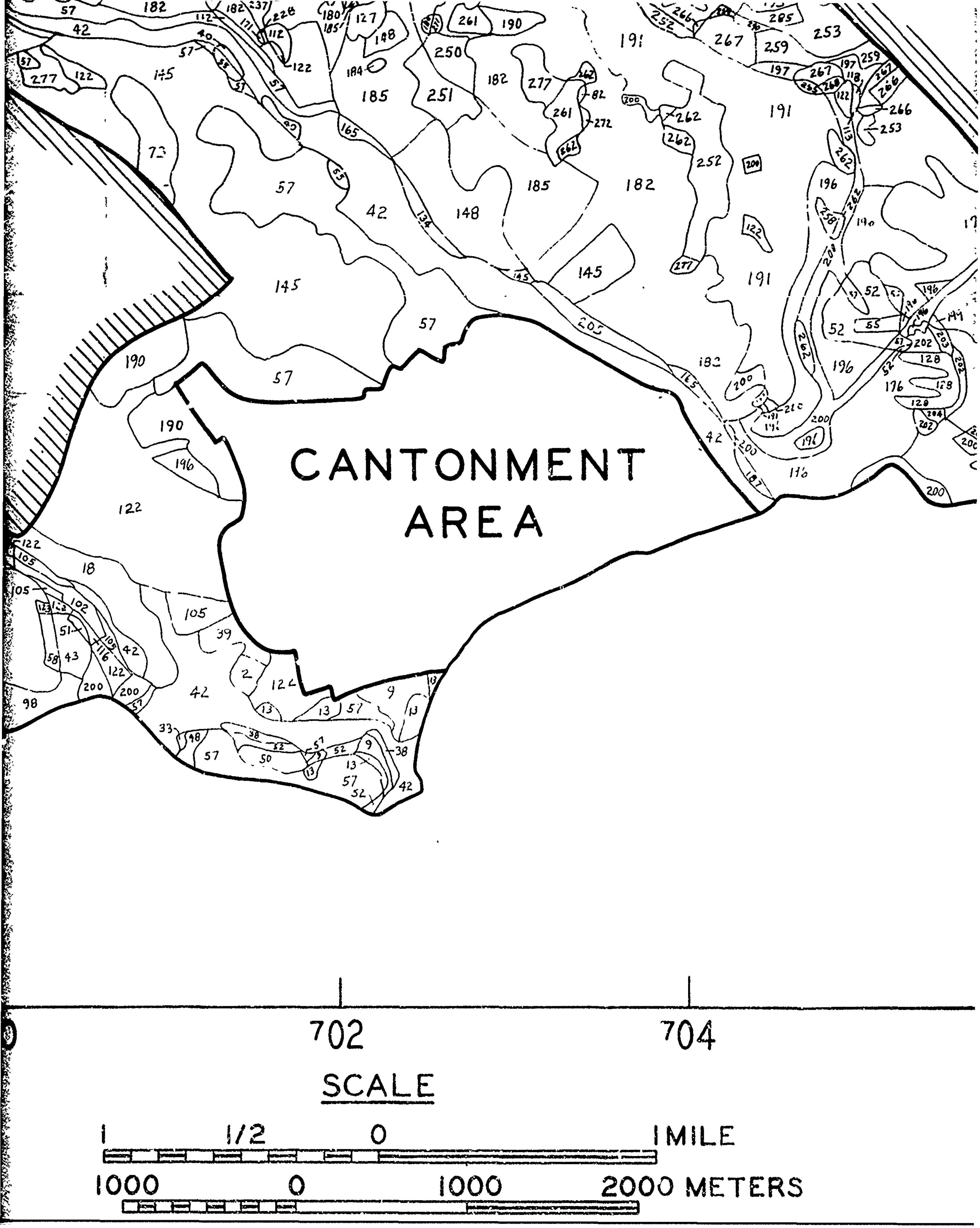


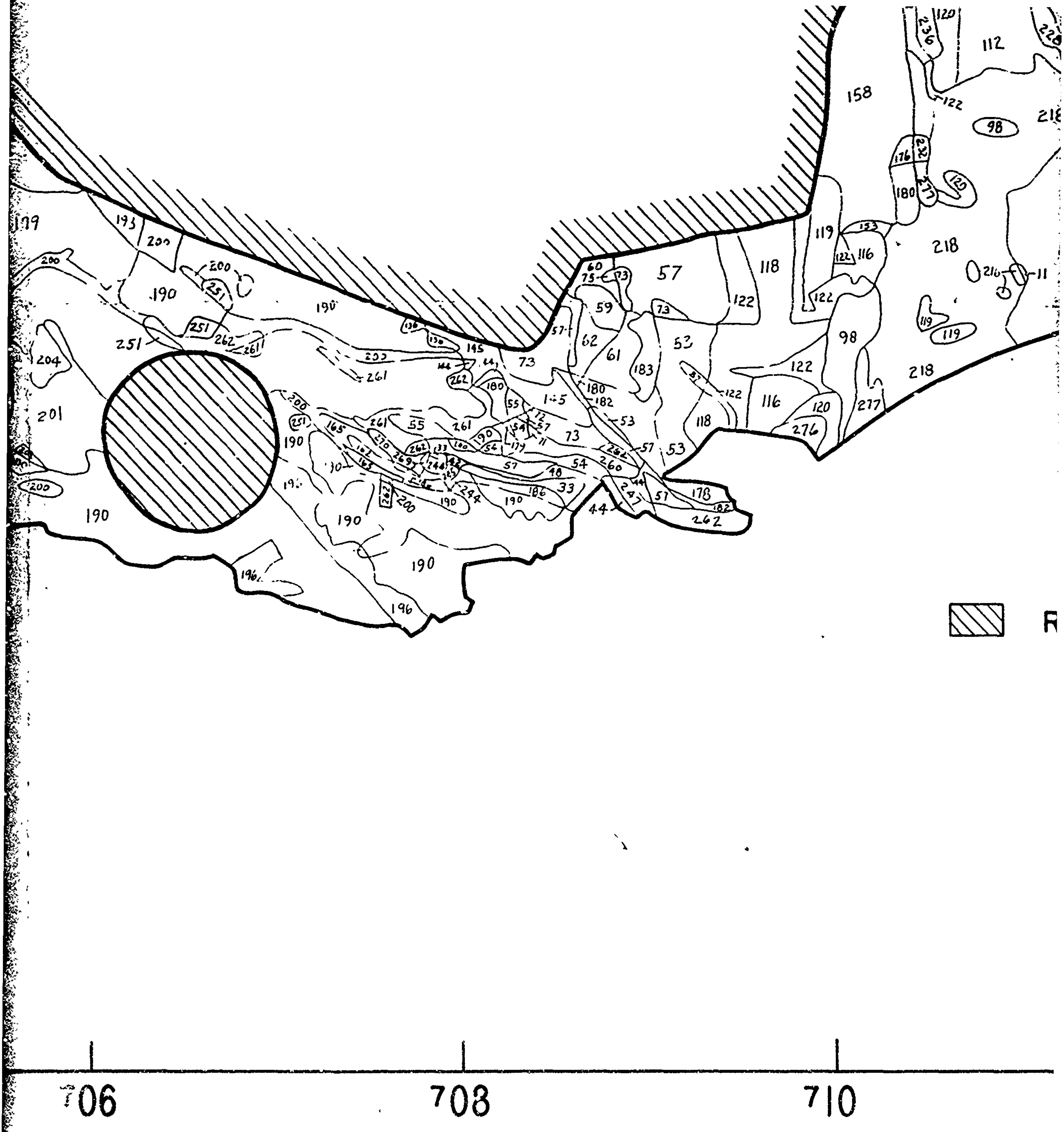

5504
5502
5500000mN
692000mE
694

AND

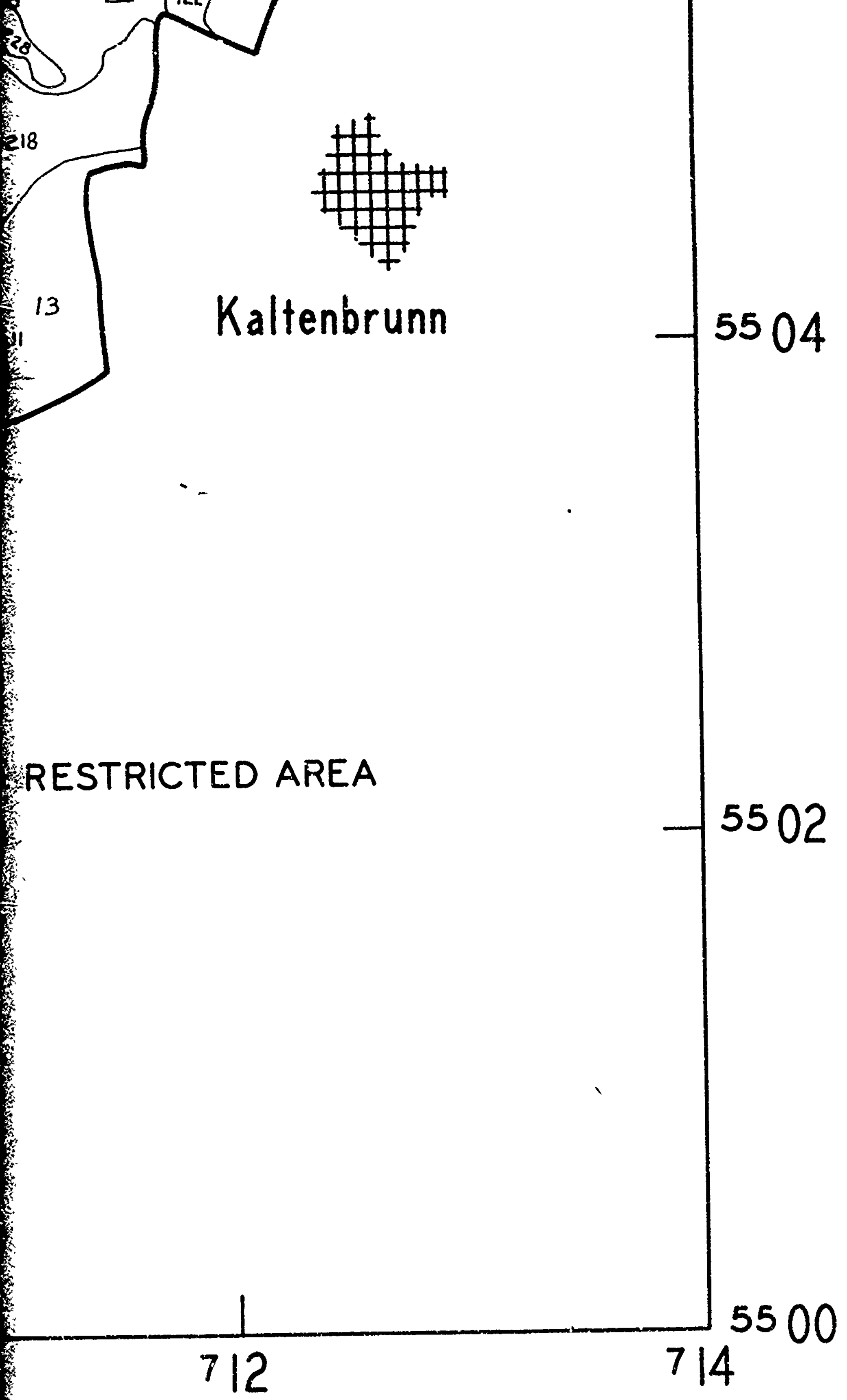
IMPACT AREA




CANTONMENT
AREA
702
704
SCALE
1 1/2 0 1 MILE
1000 0 1000 2000 METERS



706
708
710
158
112
218
57
118
122
98
73
53
190
201
204
196



233	3	1	1/1	10/10	2/2
234	3	1	1/1	10/10	2/2
235	3	1	1/1	10/10	2/2
236	3	1	1/1	10/10	2/2
237	3	1	1/1	10/10	2/2
238	3	1	1/1	10/10	2/2
239	3	1	1/1	10/10	2/2
240	3	1	1/1	10/10	2/2
241	3	1	1/1	10/10	2/2
242	3	1	2/2	10/10	3/3
243	3	1	2/2	10/10	3/3
244	3	1	2/2	10/10	3/3
245	3	1	2/2	10/10	3/3
246	3	1	2/2	10/10	3/3
247	3	1	2/2	10/10	3/3
248	3	1	2/2	10/10	3/3
249	3	1	2/2	10/10	3/3
250	3	1	2/2	10/10	3/3
251	3	1	2/2	10/10	3/3
252	3	1	2/2	10/10	3/3
253	3	1	2/2	10/10	3/3
254	3	1	2/2	10/10	3/3
255	3	1	2/2	10/10	3/3
256	3	1	2/2	10/10	3/3
257	3	1	2/2	10/10	3/3
258	3	1	2/2	10/10	3/3
259	3	1	2/2	10/10	3/3
260	3	1	2/2	10/10	3/3
261	3	1	2/2	10/10	3/3
262	3	1	2/2	10/10	3/3
263	3	1	2/2	10/10	3/3
264	3	1	2/2	10/10	3/3
265	3	2	2/2	3/10	8/8
266	3	2	2/2	3/10	8/8
267	3	2	2/2	3/10	8/8
268	3	2	2/2	3/10	8/8
269	3	2	2/2	4/4	2/2
270	3	2	2/2	4/4	2/2
271	3	2	2/2	4/4	2/2
272	3	2	2/2	4/4	2/2
273	3	2	2/2	4/4	2/2
274	3	2	2/2	4/4	2/2
275	3	2	2/2	4/4	2/2
276	3	2	2/2	4/4	2/2
277	3	2	2/2	4/4	2/2
278	3	2	2/2	4/4	2/2
279	4	1	1/1	10/10	2/2
280	4	1	1/1	10/10	2/2
281	4	1	1/1	10/10	2/2
282	4	1	1/1	10/10	2/2
283	4	1	1/1	10/10	2/2
284	4	1	1/1	10/10	2/2
285	4	1	1/1	10/10	2/2
286	4	1	1/1	10/10	2/2
287	4	1	1/1	10/10	2/2
288	4	1	1/1	10/10	2/2
289	4	1	1/1	10/10	2/2
290	4	1	1/1	10/10	2/2

0	2/2	7	3	3	3	3	4	4	4	7
0	2/2	7	3	3	4	4	4	5	5	4
0	2/2	7	4	4	4	4	4	5	5	7
0	2/2	7	6	6	6	6	6	6	7	7
0	2/2	7	7	7	7	7	7	7	7	7
0	2/2	7S	2	2	2	2	2	4	6	7
0	2/2	7S	2	2	2	2	3	4	5	7
0	2/2	7S	3	3	3	3	3	4	5	7
0	2/2	7S	7	7	7	7	7	7	7	7
0	3/3	2M	7	7	7	7	7	7	7	7
0	3/3	6M	2	2	2	2	2	3	4	7
0	3/3	6M	2	2	2	2	3	4	4	7
0	3/3	6M	7	7	7	7	7	7	7	7
0	3/3	7	1	1	1	22	2	4	7	4
0	3/3	7	1	1	2	4	7	7	7	7
0	3/3	7	1	1	2	4	7	7	7	7
0	3/3	7	2	2	2	2	2	3	4	7
0	3/3	7	2	2	2	2	3	3	4	7
0	3/3	7	2	2	2	2	3	4	4	7
0	3/3	7	2	2	2	2	3	4	5	7
0	3/3	7	2	2	2	2	4	6	7	7
0	3/3	7	2	2	2	2	4	7	7	7
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0	3/3	7	3	3	3	3	3	4	4	7
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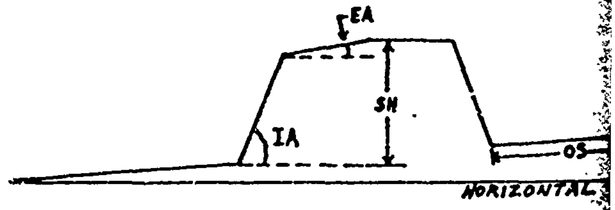
0	3/3	7	3	3	3	3	4	4	4	7
0	3/3	7	3	3	4	4	4	5	5	4
0	3/3	7	3	3	3	3	3	5	5	7
0	3/3	7	6	6	6	6	6	6	7	7
0	3/3	7	7	7	7	7	7	7	7	7
0	3/3	7S	3	3	3	3	3	4	5	7
0	3/3	7S	7	7	7	7	7	7	7	7
	8/8	7	2	2	2	2	3	4	5	7
	8/8	7	2	2	2	2	4	6	7	7
	8/8	7	3	3	4	4	4	5	5	4
	8/8	7	7	7	7	7	7	7	7	7
	2/2	6M	2	2	2	2	3	4	4	7
	2/2	6M	7	7	7	7	7	7	7	7
	2/2	7	2	2	2	2	3	4	4	7
	2/2	7	2	2	2	2	3	4	5	7
	2/2	7	3	3	3	3	3	4	5	7
	2/2	7	3	3	3	3	4	4	4	7
	2/2	7	3	3	4	4	4	5	5	4
	2/2	7	6	6	6	6	6	6	7	7
	2/2	7	7	7	7	7	7	7	7	7
	2/2	7S	7	7	7	7	7	7	7	7
10	2/2	6M	2	2	2	2	2	3	4	7
10	2/2	7	1	1	1	2	2	4	7	7
10	2/2	7	2	2	2	2	2	2	3	7
10	2/2	7	2	2	2	2	2	3	4	7
10	2/2	7	2	2	2	2	3	4	5	7
10	2/2	7	2	2	2	2	3	6	7	7
10	2/2	7	2	2	2	2	4	6	7	7
10	2/2	7	2	2	2	2	4	7	7	7
10	2/2	7	3	3	3	3	3	3	4	7
10	2/2	7	3	3	3	3	3	4	5	7
10	2/2	7	3	3	3	3	4	4	4	7
10	2/2	7	3	3	4	4	4	5	5	4

306	5	1	3/3	7/7	7/7	7
307	5	1	3/3	7/7	7/7	7
308	5	1	3/3	7/7	7/7	7
309	5	1	3/3	7/7	7/7	7
310	5	1	3/3	7/7	7/7	7
311	5	1	3/3	7/7	7/7	7
312	5	1	3/3	7/7	7/7	7
313	5	1	3/3	7/7	7/7	7
314	5	1	3/3	7/7	7/7	7
315	5	1	3/3	7/7	7/7	7
316	5	1	3/3	7/7	7/7	7S
317	5	1	3/3	7/7	7/7	7S
318	5	3	2/2	10/10	8/8	7
319	6	1	2/2	10/10	8/8	7
320	6	1	2/2	10/10	8/8	7
321	6	1	2/2	10/10	8/8	7
322	6	1	2/2	10/10	8/8	7
324	6	1	2/2	10/10	8/8	7
324	6	1	2/2	10/10	8/8	7
325	6	1	2/2	10/10	8/8	7
326	6	1	2/2	10/10	8/8	7
327	6	1	2/2	10/10	8/8	7
328	6	1	2/2	10/10	8/8	7S
329	8	1	3/3	10/10	8/8	7
330	8	1	3/3	10/10	8/8	7
331	8	1	3/3	10/10	8/8	7

7	1	1	1	2	2	4	7		7
7	2	2	2	2	2	3	4		7
7	2	2	2	2	3	4	4		7
7	2	2	2	2	4	6	7		7
7	2	2	2	2	4	7	7		7
7	3	3	3	3	3	3	4		7
7	3	3	3	3	3	4	5		7
7	3	3	3	3	4	4	4		7
7	4	4	4	4	4	5	5		7
7	6	6	6	6	6	6	7		7
7	7	7	7	7	7	7	7		7
7S	6	6	6	6	6	6	7		7
7S	7	7	7	7	7	7	7		7
7	3	3	3	3	3	4	5		7
7	2	2	2	2	2	3	4		7
7	22	2	2	2	3	6	7		7
7	3	3	3	3	3	3	4		7
7	3	3	4	3	3	4	5		7
7	3	3	3	3	4	4	4		7
7	3	3	4	4	4	5	5		4
7	4	4	4	4	4	5	5		7
7	6	6	6	6	6	6	7		7
7	7	7	7	7	7	7	7		7
7S	7	7	7	7	7	7	7		7
7	2	2	2	2	2	3	4		7
7	4	4	4	4	4	5	5		7
7	7	7	7	7	7	7	7		7

7	>27-31
8	>31

7
8
9
10



** Mapping class ranges for each Surf

Map Class	6-12 in RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

Map Class	0-
1S	0-
2S	>20
3S	>40
4S	>75
5S	>12
6S	>17
7S	>25

*** Mapping class ranges for each spacing

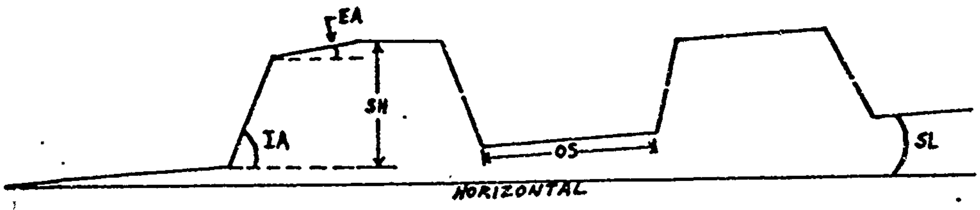
Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

TERRAIN FACTOR C
WEST GERM

AREAL FACTOR

GRAFEN

9	>36-45
10	>45



**Mapping class ranges for each Surface Composition unit are:

Map Class	6-12 in RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

Map Class	0-6 in CI
1S	0-20
2S	>20-40
3S	>40-75
4S	>75-125
5S	>125-175
6S	>175-250
7S	>250

Map Class	6-12 in CI
1M	0-15
2M	>15-30
3M	>30-45
4M	>45-60
5M	>60-80
6M	>80

***Mapping class ranges for each spacing class and visibility class are:

Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

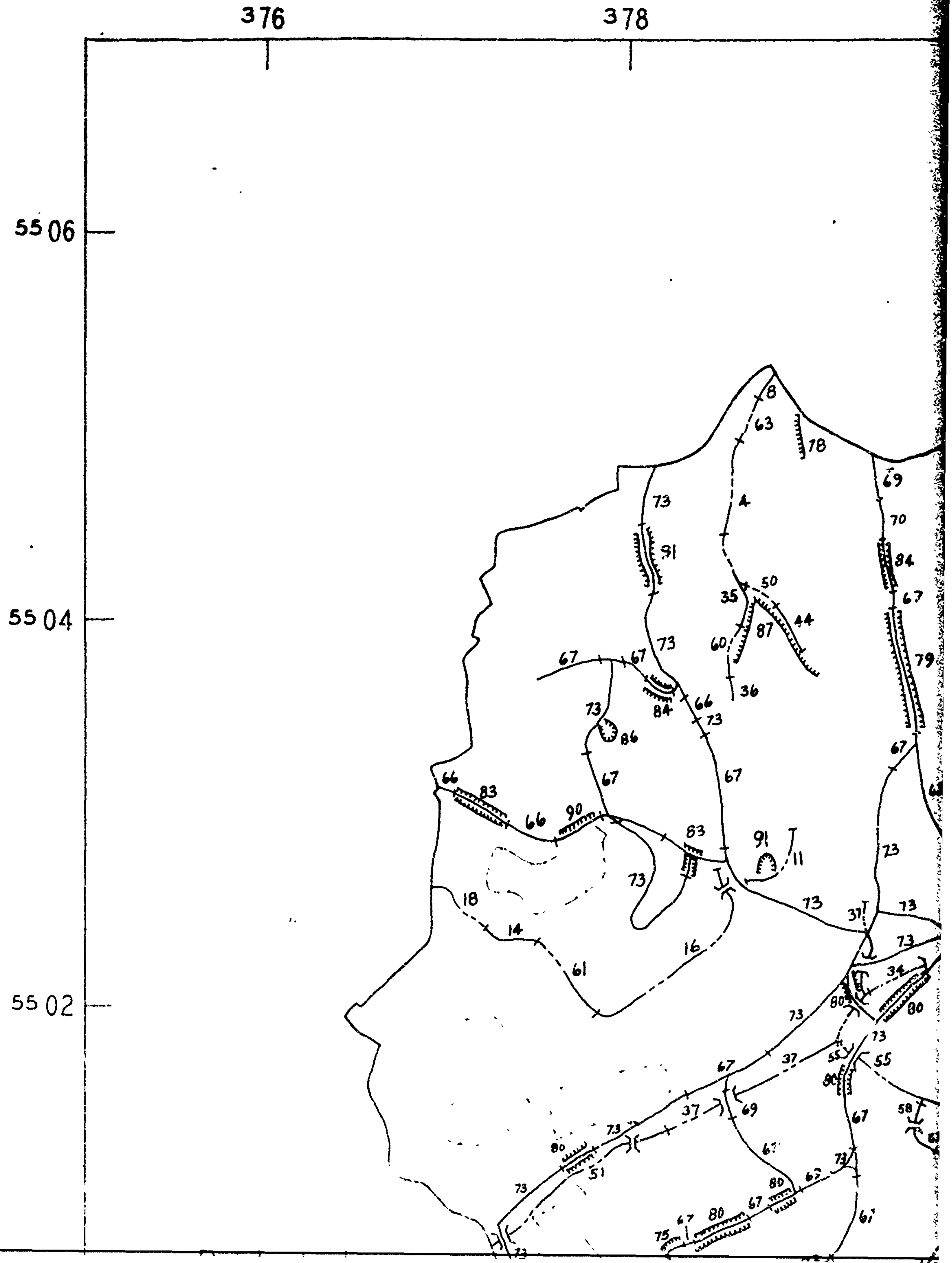
Visibility	
Map Class	ft
1	<15
2	15-21
3	> 21-27
4	> 27-33
5	> 33-39
6	> 39-45
7	> 45

TERRAIN FACTOR COMPLEX MAP
WEST GERMANY
AREAL FACTOR COMPLEXES
GRAFENWOHR

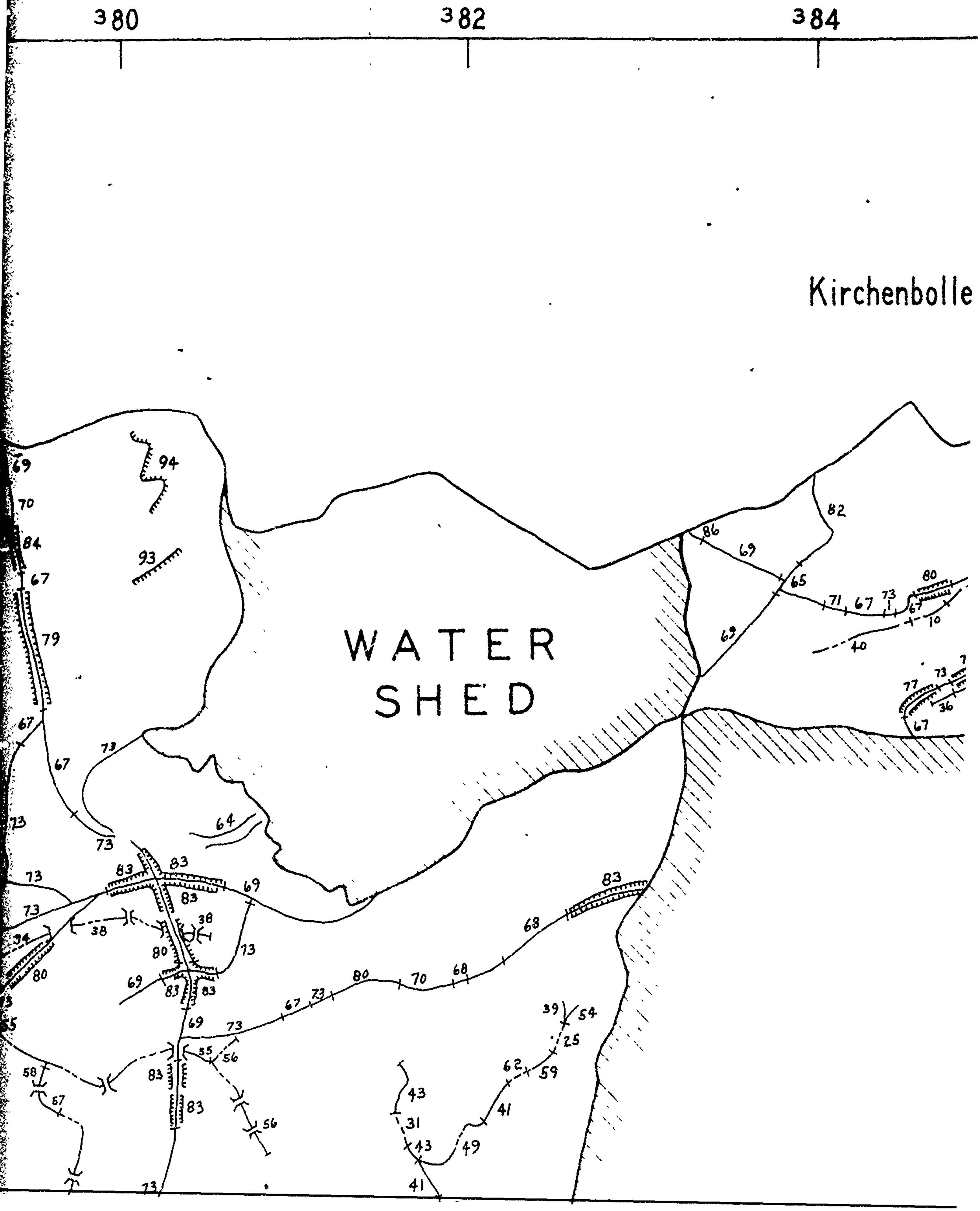
PLATE 3

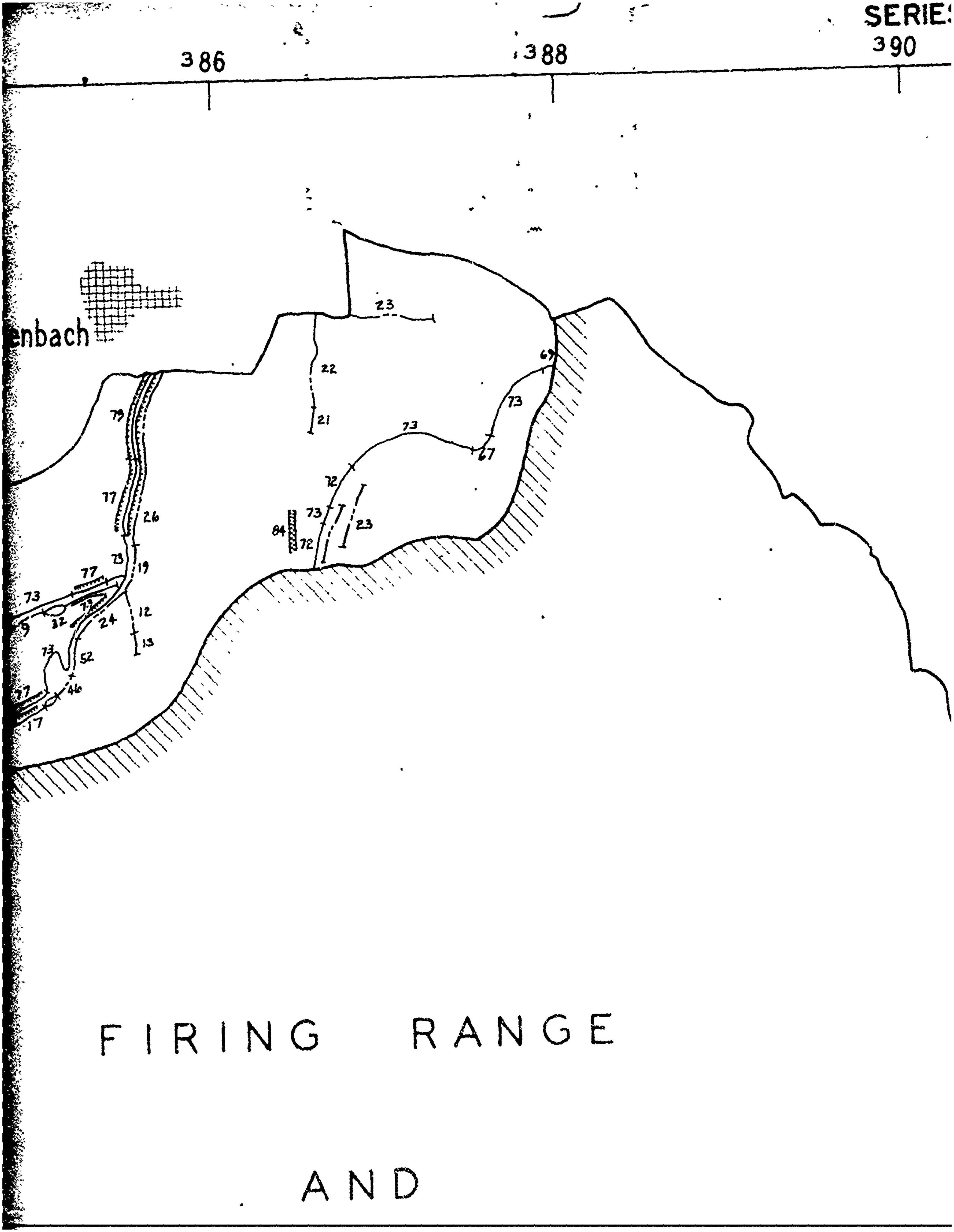
BAUMHOLDER

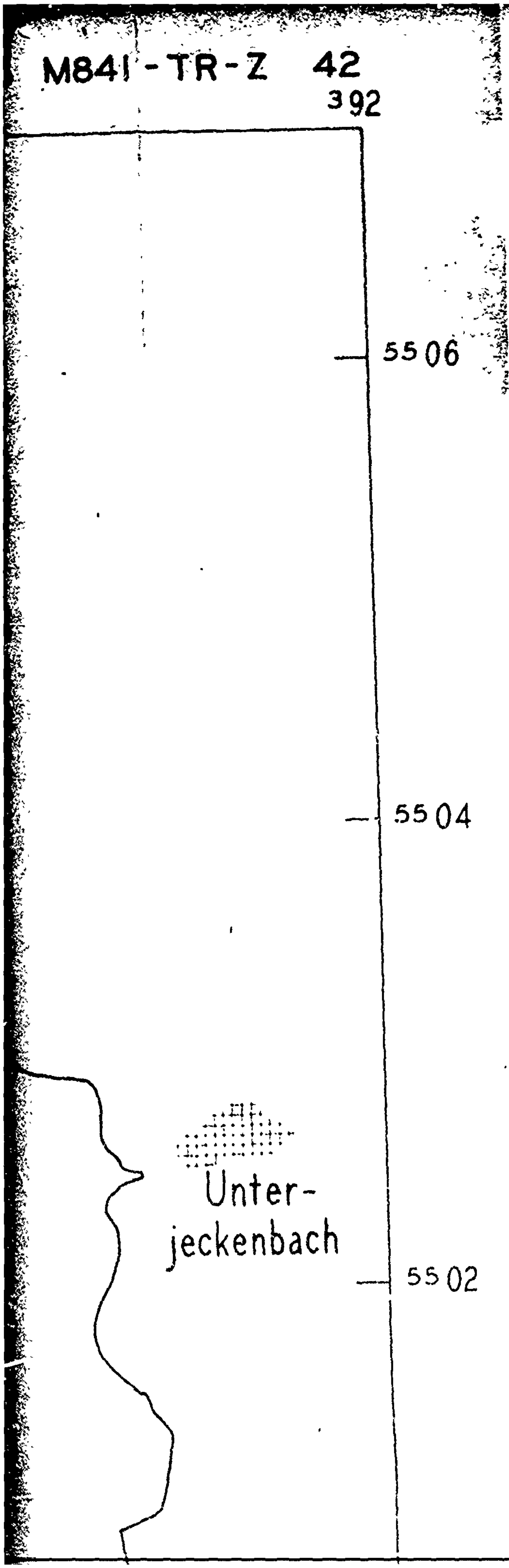
BAUMHOLDER



2




SERIE
386
388
390
enbach
FIRING RANGE
AND



Map[†] Unit	HYDROLOGIC GEOMETRY*										SURFACE[**] COMPOSITION
	West Bank				East Bank				Stream		
	EA	IA	SH	PS	EA	IA	SH	PS	Width	Depth	
1	1	7	8		1	10	8		3	1	6
2	1	7	8		1	10	8		3	1	7
3	1	7	8		1	10	8		3	1	7
4	1	9	7		3	6	8		2	1	7
5	1	9	7		3	6	8		2	1	7
6	1	9	7		3	6	8		2	1	7
7	1	9	7		3	6	8		2	1	7
8	1	9	7		3	6	8		2	1	7
9	1	10	7		3	6	7		1	1	6
10	1	10	7		3	6	7		1	1	6
11	1	10	8		1	1	8		1	1	6
12	1	10	8		1	10	8		1	1	7
13	1	10	8		1	10	8		1	1	7
14	1	10	8		1	10	8		1	1	7
15	1	10	8		1	10	8		1	1	7
16	1	10	8		1	10	8		1	1	7
17	1	10	8		3	10	8		1	1	5
18	1	10	8		3	10	8		2	1	7
19	1	10	8		4	10	8		1	1	7
20	2	4	7		2	4	6		1	6	6
21	2	4	7		2	4	6		1	1	6
22	2	4	7		2	4	6		1	1	6
23	2	4	7		2	4	6		1	1	6
24	2	4	8		1	4	8		1	1	7
25	2	4	8		4	1	1		5	1	7
26	2	5	7		3	5	8		1	1	7
27	2	6	8		1	4	8		6	1	7
28	2	6	8		1	4	8		6	1	7
29	2	6	8		2	4	8		5	1	7
30	2	6	8		2	4	8		5	1	7
31	2	6	8		2	6	8		1	1	7
32	3	7	8		2	10	8		1	1	7
33	2	10	7		1	9	8		3	1	6
34	2	10	7		1	9	8		3	1	6
35	2	10	7		1	10	7		1	1	5
36	2	10	7		1	10	7		1	1	5
37	2	10	7		3	10	8		1	1	6
38	2	10	8		3	10	8		2	1	6
39	3	4	8		4	5	8		2	1	7
40	3	10	3		3	10	3		1	1	6
41	3	10	6		3	10	6		1	1	7
42	2	10	6		3	10	6		1	1	6
43	3	10	6		3	10	6		1	1	7
44	3	10	7		7	10	8		1	1	7
45	3	10	8		1	9	8		1	1	6
46	3	10	8		1	10	8		1	1	7
47	3	10	8		1	10	8		2	1	7
48	3	10	8		2	9	8		2	1	6
49	2	10	8		3	8	8		2	1	7
50	3	10	8		3	10	8		1	1	6
51	3	10	8		3	10	8		1	1	6

VEGETATION***							
Spacing of stems > the Specified diameter, in							Visibility
1.0	2.5	4.0	5.5	7.0	8.5	10.0	
7	7	7	7	7	7	7	7
2	2	2	2	2	3	5	7
7	7	7	7	7	7	7	7
1	1	1	4	5	5	5	7
1	2	2	3	5	7	7	7
2	2	2	2	2	3	5	7
2	2	2	2	3	5	7	7
2	3	4	4	5	7	7	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
3	3	3	3	3	4	5	7
1	1	1	7	7	7	7	1
2	3	4	4	5	7	7	7
3	3	3	3	3	4	5	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
2	3	4	4	5	7	7	7
7	7	7	7	7	7	7	
4	4	4	4	4	7	7	7
3	3	3	3	3	4	5	7
6	6	6	6	6	6	6	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
2	2	3	4	7	7	7	7
7	7	7	7	7	7	7	7
4	4	4	4	4	4	5	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
4	4	4	4	4	5	5	7
7	7	7	7	7	7	7	7
1	1	1	4	5	5	5	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
6	6	6	6	6	6	7	7
7	7	7	7	7	7	7	7
2	3	4	4	5	7	7	7
6	6	6	6	6	6	7	7
7	7	7	7	7	7	7	7
1	1	2	7	7	7	7	4
2	2	2	2	2	3	5	7
7	7	7	7	7	7	7	7
4	4	4	4	4	4	5	7
7	7	7	7	7	7	7	7
2	3	4	4	5	7	7	7
2	3	3	4	4	5	5	7

LEGEND

†Hydrologic geometry units 1 - 63 represent class ran
Diagram below), step height SH, position of step bas
depth SD. The west bank is the first bank encounter
azimuth > 0 to 180 deg) and the east bank is the firs
ection (i.e. azimuth > 180 to 360 deg), assuming that

††Surface geometry units 64 - 94 represents class range
Surface Geometry Diagram below). Fractional designat
the fraction indicates class ranges that will be enco
azimuth from > 0 to 180 deg) and the denominator refer
assuming that the vehicle intersects the feature at a

Class ranges for each factor are:

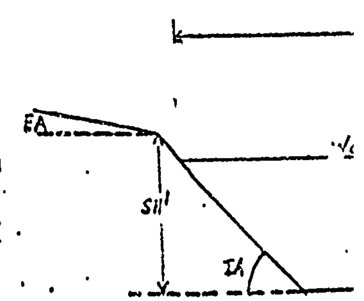
Hyd

Approach Angle (FA-IA)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45

Step Height (SH)		
Map Class	Step Height (SH) in[1]	in[2]
1	<8	<12
2	8-10	12-24
3	>10-12	>24-36
4	>12-14	>36-48
5	>14-16	>48
6	>16-20	
7	> 20-30	
8	> 30	
x		absent

F St	
Map Class	
1	>4
2	>3
3	>1
4	1-
5	a
6	1-
7	>1
8	>3
9	>4
x	a

1 step height class ranges used when water depth is
2 step height class ranges used when water depth is
3 below water level
4 above water level



Surf

Approach Angle (F	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10

nt class ranges of approach angles (EA and IA, see Hydrologic Geometry of step baso PS, referenced to water level, stream width SW, and stream nk encountered while traversing an area in an easterly direction (i.e. is the first bank encountered while traversing an area in a westerly dir- assuming that the vehicle intersects the feature at a right angle.

class ranges of approach angles EA and IA, and step height SH (see nal designations indicate that dual classes were mapped. The numerator of will be encountered while traversing an area in an easterly direction (i.e. inator refers to a westerly direction (i.e. azimuth from > 180 to 360 deg) feature at a right angle.

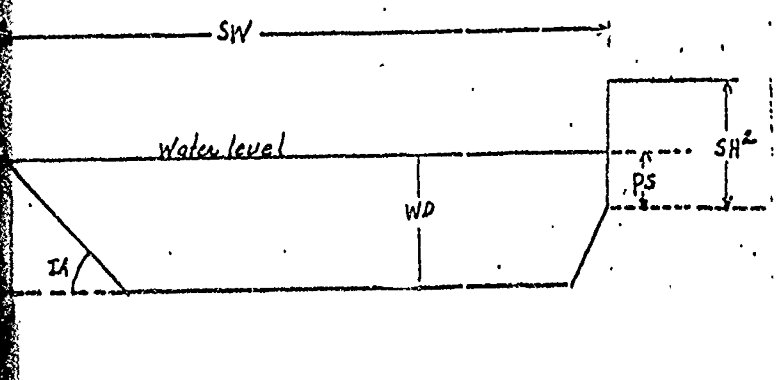
Hydrologic Geometry*

Position of Step Base (PS)	
Map Class	in
1	> 48
2	> 36-48
3	> 18-36 bwl[3]
4	1-18
5	at water level
6	1-12
7	> 12-30 awl[4]
8	> 30-48
9	> 48
x	absent

Stream Width (SW)	
Map Class	ft
1	0-5
2	> 5-10
3	> 10-15
4	> 15-20
5	> 20-25
6	> 25-30
7	> 30

Stream Depth (SD)	
Map Class	ft
1	< 3
2	3-4.5
3	> 4.5-15
4	> 15

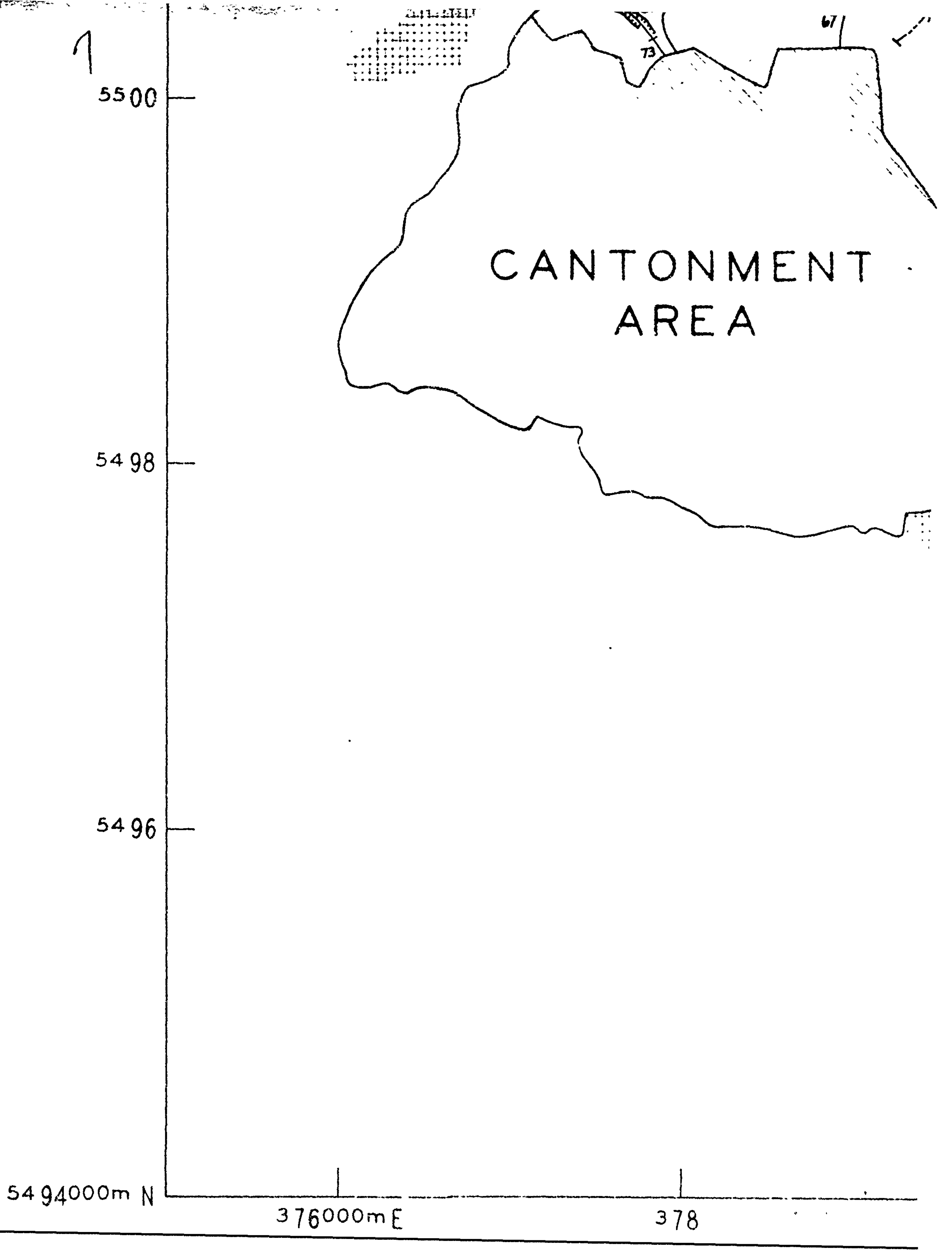
r depth is < 3 ft
r depth is ≥ 3 ft

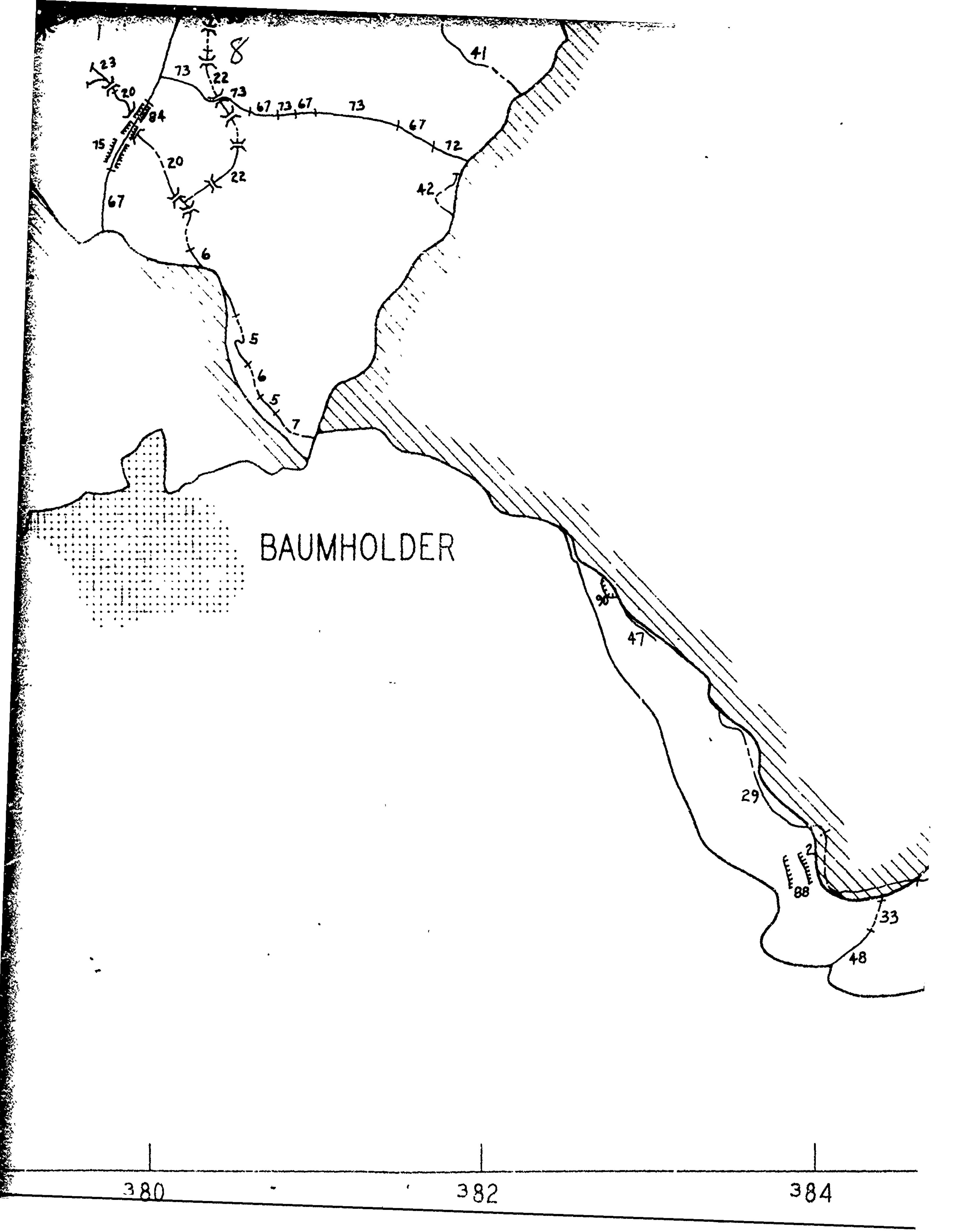


Surface Geometry

ach Angle (EA-IA)	
s	deg
	0-1.5
	> 1.5-4.5
	> 4.5-10

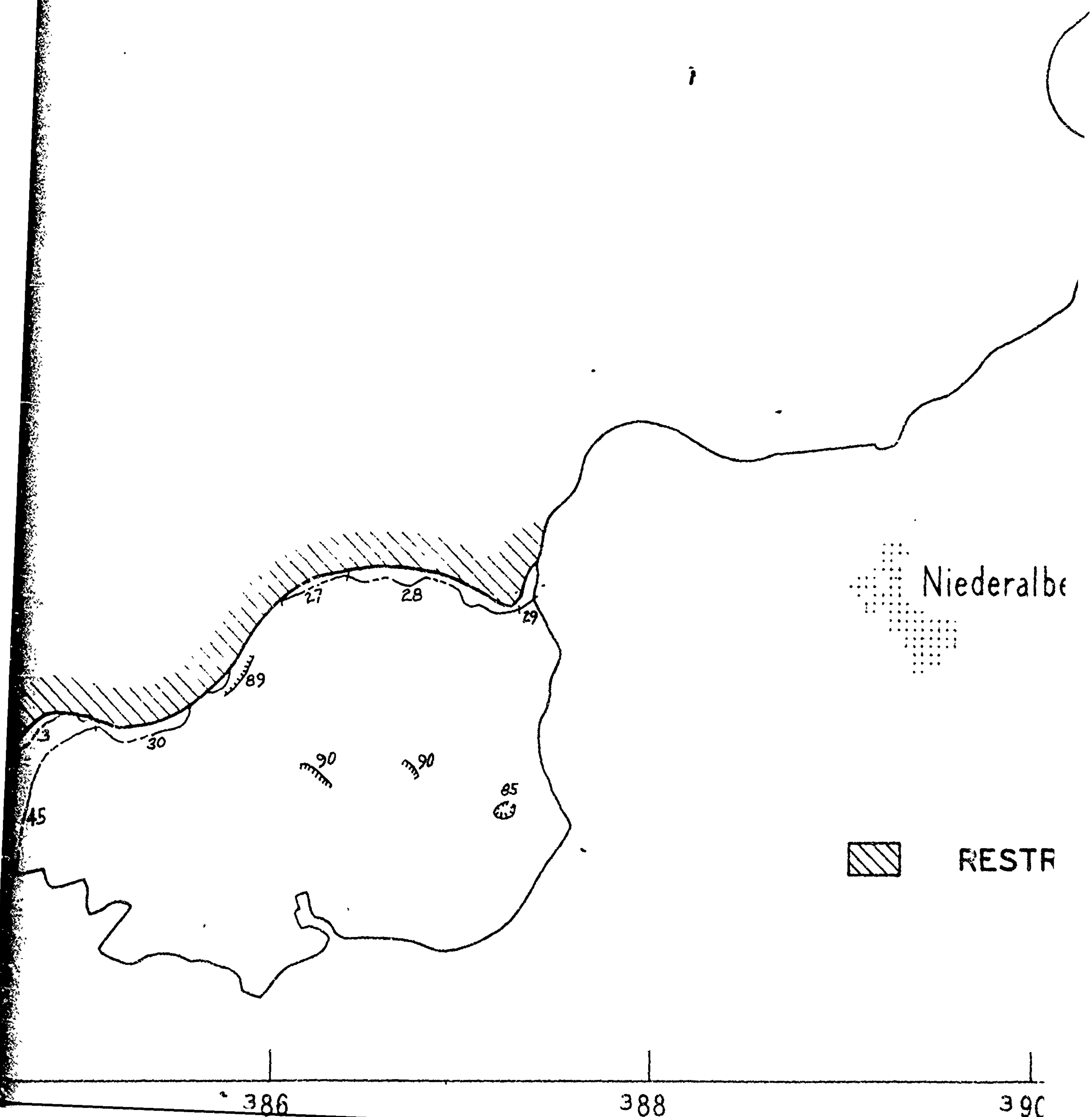
Step Height (SH)	
Map Class	in
1	< 8
2	8-10
3	> 10-12

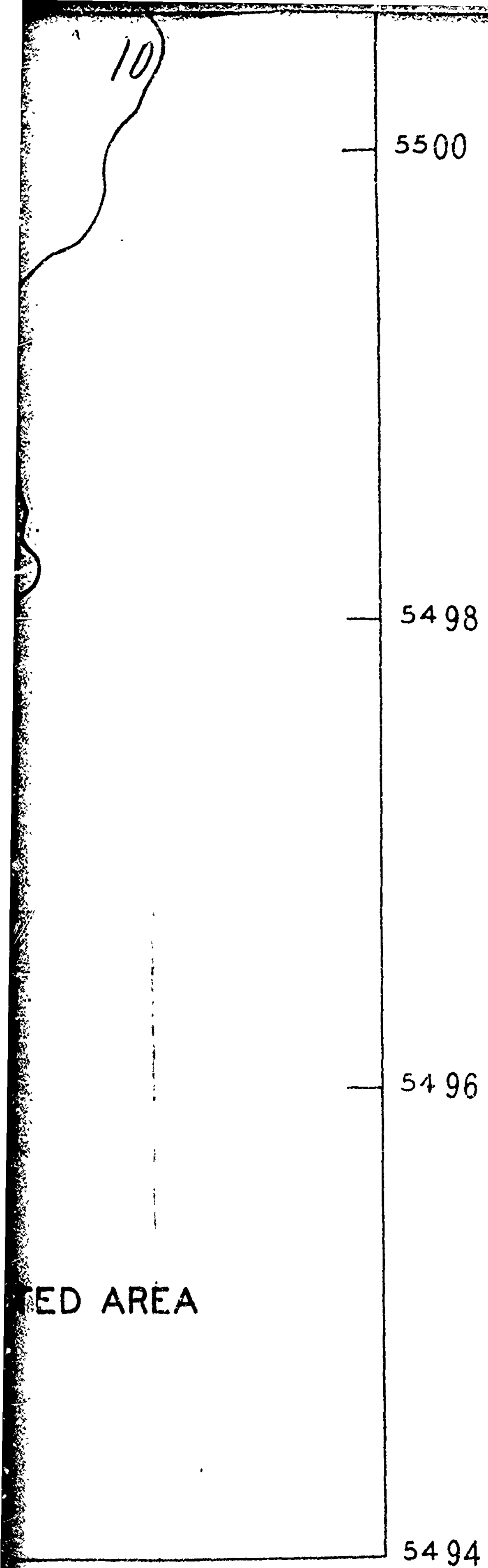

1
5500
5498
5496
5494000m N
376000m E
378
CANTONMENT
AREA
73
67


8
41
23
20
84
75
73
22
73
67
73
67
73
67
72
42
20
22
67
6
5
6
5
7
BAUMHOLDER
90
47
29
2
88
33
48
380
382
384

1 9

IMPACT AREAS





54	4	5	8		3	4	8		1	1	7	7
55	4	8	8		2	7	8		1	1	5	2
56	4	8	8		2	7	8		1	1	5	6
57	5	10	5		4	10	6		1	1	5	4
58	5	10	5		4	10	6		1	1	5	7
59	6	3	8		3	6	8		4	1	6	4
60	6	10	7		1	10	8		1	1	5	1
61	6	10	8		2	4	6		1	1	7	2
62	7	8	8		3	9	8		3	1	7	4
63	9	10	7		7	10	8		1	1	7	2

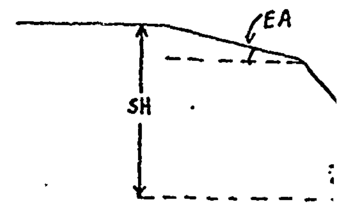
Map[††] Unit	SURFACE GEOMETRY[◊] Exterior Angle	Interior Angle	Step Height	SURFACE COMPOSI-TION	Spac Spec 1.0	2.5
64	1/3	10/7	7/6	7	6	6
65	2/2	7/7	5/5	7	1	1
66	2/2	7/7	5/5	7	1	2
67	2/2	7/7	5/5	7	2	2
68	2/2	7/7	5/5	7	4	4
69	2/2	7/7	5/5	7	4	4
70	2/2	7/7	5/5	7	5	5
71	2/2	7/7	5/5	7	6	6
72	2/2	7/7	5/5	7	6	6
73	2/2	7/7	5/5	7	7	7
74	2/3	7/8	4/7	7	7	7
75	2/7	6/9	8/7	7	6	6
76	3/1	9/1	8/1	7	7	7
77	3/1	10/1	8/1	7	1	1
78	3/1	10/1	8/1	7	2	3
79	3/1	10/1	8/1	7	7	7
80	3/3	9/9	8/8	7	7	7
81	3/3	10/10	5/6	7	1	2
82	3/3	10/10	5/6	7	4	4
83	3/3	10/10	8/8	7	7	7
84	5/3	10/9	8/8	7	7	7
85	5/5	10/10	8/8	7	2	2
86	5/5	10/10	8/8	7	7	7
87	7/1	10/1	8/1	7	1	1
88	7/1	10/1	8/1	7	2	2
89	7/1	10/1	8/1	7	2	2
90	7/1	10/1	8/1	7	7	7
91	7/7	10/10	8/8	7	7	7
92	8/3	10/10	8/8	7	7	7
93	9/1	10/1	8/1	7	5	5
94	9/1	10/1	8/1	7	7	7

12

7	7	7	7	7	7	7
3	3	4	4	5	5	7
6	6	6	6	6	6	7
4	4	4	4	5	5	7
7	7	7	7	7	7	7
4	4	4	4	5	5	7
1	1	4	5	5	5	7
3	3	4	4	5	5	7
4	4	4	4	5	5	7
3	4	4	5	7	7	7

VEGETATION						
...acing of Stems > the ...ecified Diameter, in.						
5	4.0	5.5	7.0	8.5	1[illegible].0	Visibility
	6	6	6	6	6	7
	1	2	6	7	7	2
	2	3	5	7	7	7
	2	2	2	3	5	7
	4	4	4	4	4	7
	4	4	4	5	5	7
	5	5	5	5	5	7
	6	6	6	6	6	7
	6	6	6	6	7	7
	7	7	7	7	7	7
	7	7	7	7	7	7
	6	6	6	6	6	7
	7	7	7	7	7	7
	1	2	6	7	7	2
	4	4	5	7	7	7
	7	7	7	7	7	7
	7	7	7	7	7	7
	2	3	5	7	7	7
	4	4	4	5	5	7
7	7	7	7	7	7	7
7	7	7	7	7	7	7
2	3	4	7	7	7	7
7	7	7	7	7	7	7
1	1	4	5	5	5	7
2	2	2	2	3	5	7
2	3	4	7	7	7	7
7	7	7	7	7	7	7
7	7	7	7	7	7	7
7	7	7	7	7	7	7
5	5	5	5	5	5	7
7	7	7	7	7	7	7

7	>27-31
8	>31-36
9	>36-45
10	>45



Surfa

Map Class	6-12 in RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

Map Class
1S
2S
3S
4S
5S
6S
7S

Ve

Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

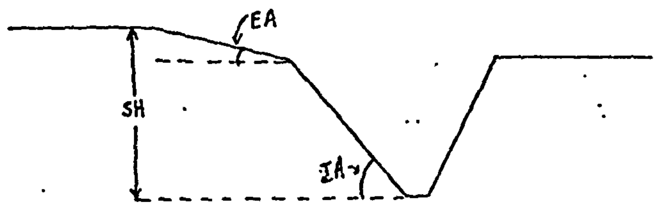
TERR

LINEAR

6	> 22-27
7	> 27-31
8	> 31-36
9	> 36-45
10	> 45

6	> 16-20
7	> 20-30
8	> 30

, 3



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Surface Composition**

6-12 in RCI
10
>10-20
>20-35
>35-50
>50-75
>75-125
>125

Map Class	0-6 in CI
1S	0-20
2S	> 20-40
3S	> 40-75
4S	>75-125
5S	>125-175
6S	>175-250
7S	> 250

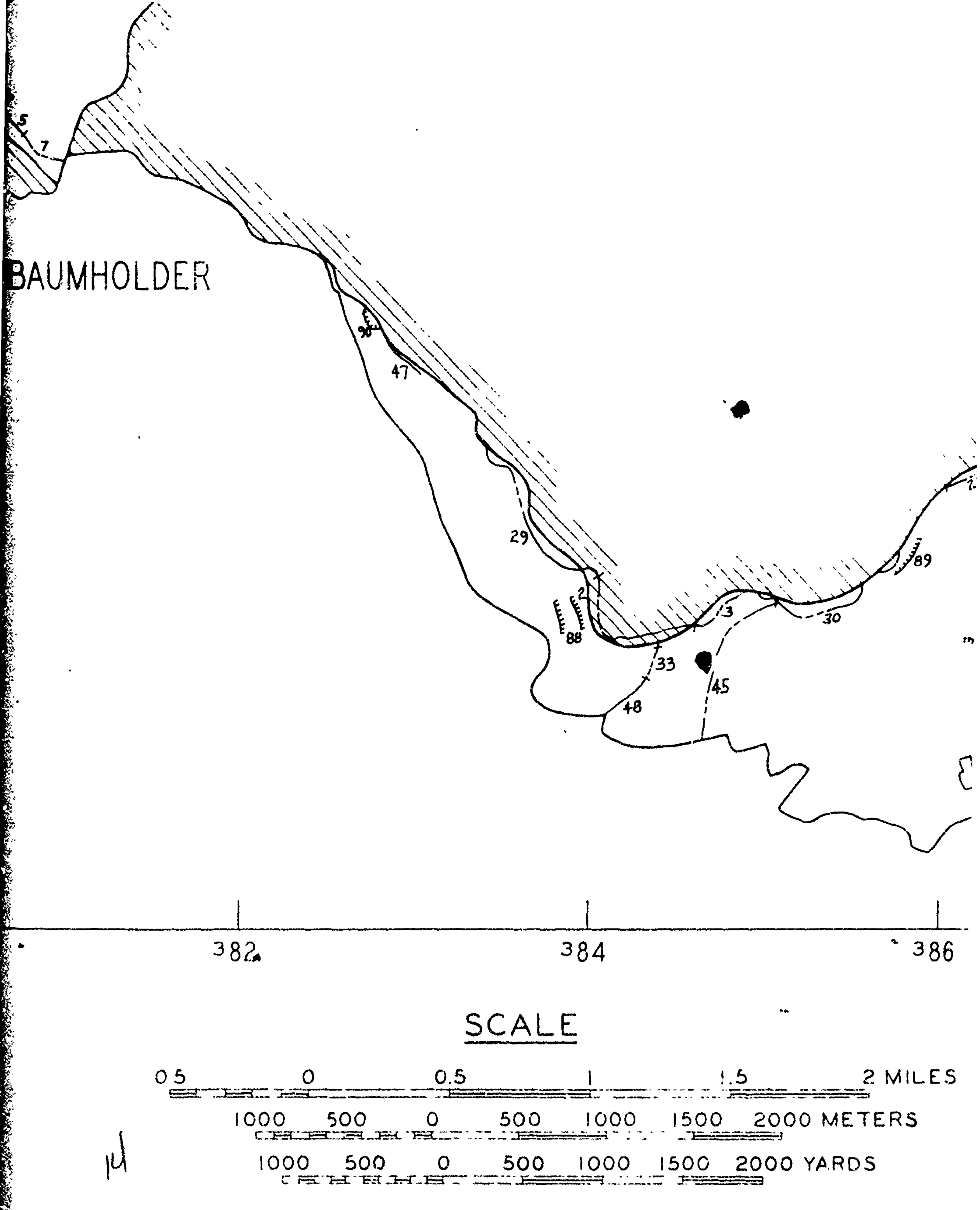
Map Class	6-12 in CI
1M	0-15
2M	>15-30
3M	>30-45
4M	>45-60
5M	>60-80
6M	>80

Vegetation ***

tem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

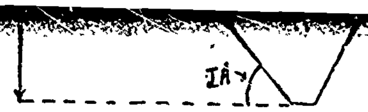
Visibility	
Map Class	ft
1	< 15
2	> 15-21
3	> 21-27
4	> 27-33
5	> 33-39
6	> 39-45
7	> 45

TERRAIN FACTOR COMPLEX MAP



BAUMHOLDER
5
7
90
47
29
2
88
3
30
89
33
45
48
382
384
386
SCALE
0.5 0 0.5 1 1.5 2 MILES
1000 500 0 500 1000 1500 2000 METERS
1000 500 0 500 1000 1500 2000 YARDS

14



Surface Composition**

Map Class	6-12 in RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

Map Class	0-6 in CI
1S	0-20
2S	> 20-40
3S	> 40-75
4S	>75-125
5S	> 125-175
6S	> 175-250
7S	> 250

Map Class	6-12 in CI
1M	0-15
2M	>15-30
3M	>30-45
4M	>45-60
5M	>60-80
6M	>80

Vegetation ***

Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

Visibility	
Map Class	ft
1	< 15
2	> 15-21
3	> 21-27
4	> 27-33
5	> 33-39
6	> 39-45
7	> 45

TERRAIN FACTOR COMPLEX MAP
WEST GERMANY
LINEAR FACTOR COMPLEXES
BAUMHOLDER

BERGEN HOHNE

NATO CAMP BERGEN HOHNE

546 548

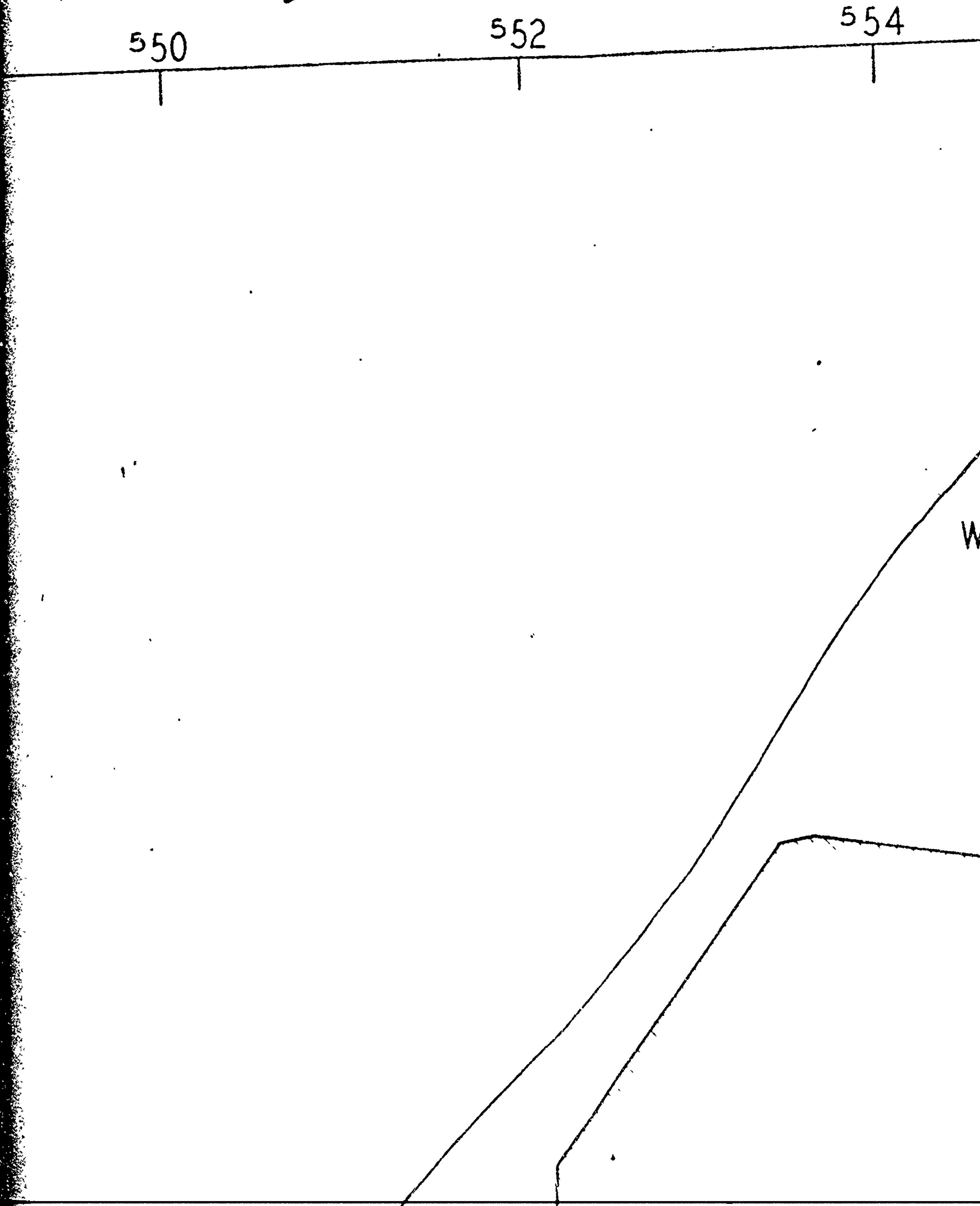
5866

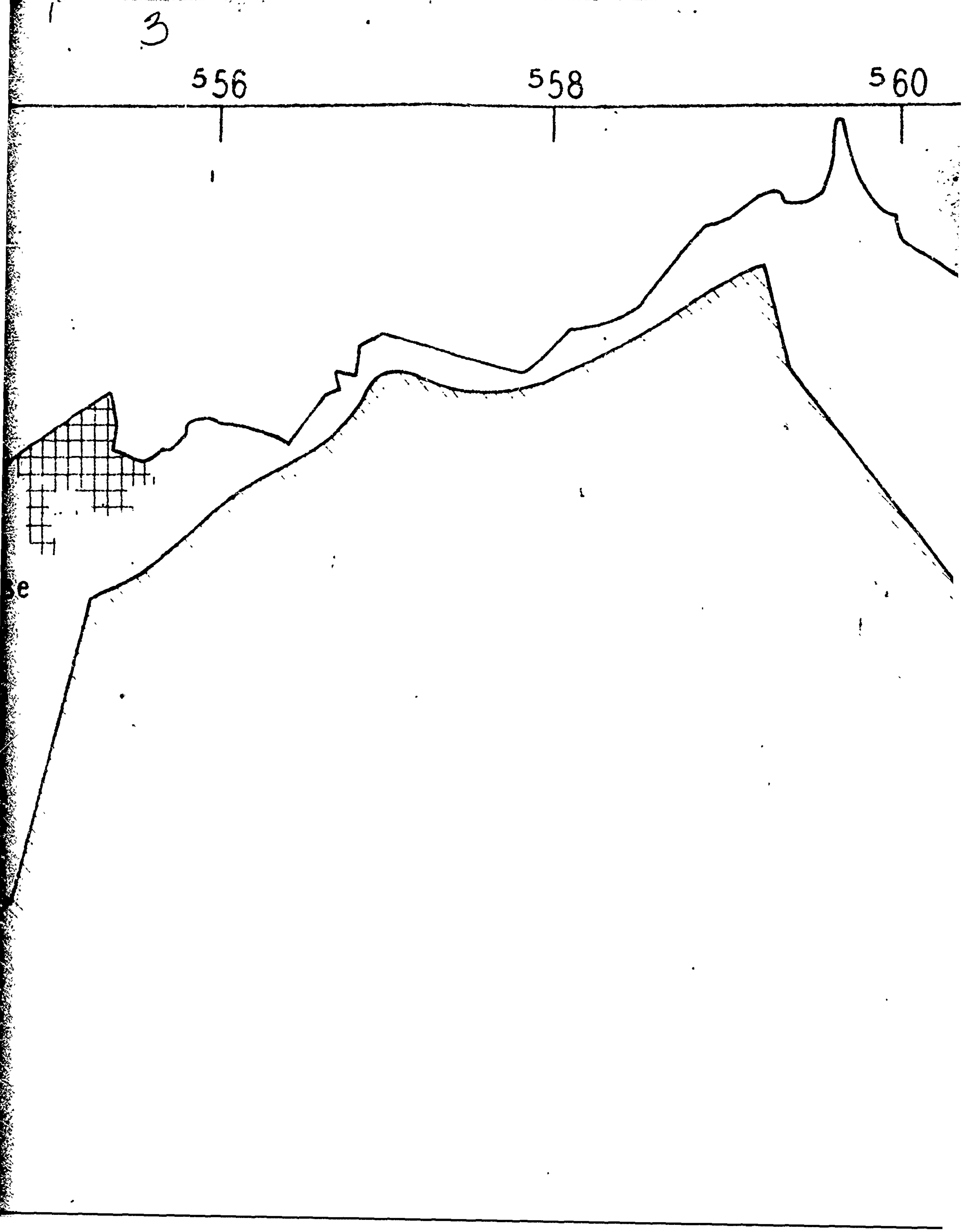
5864

5862

5860

1 2




3
556
558
560
e

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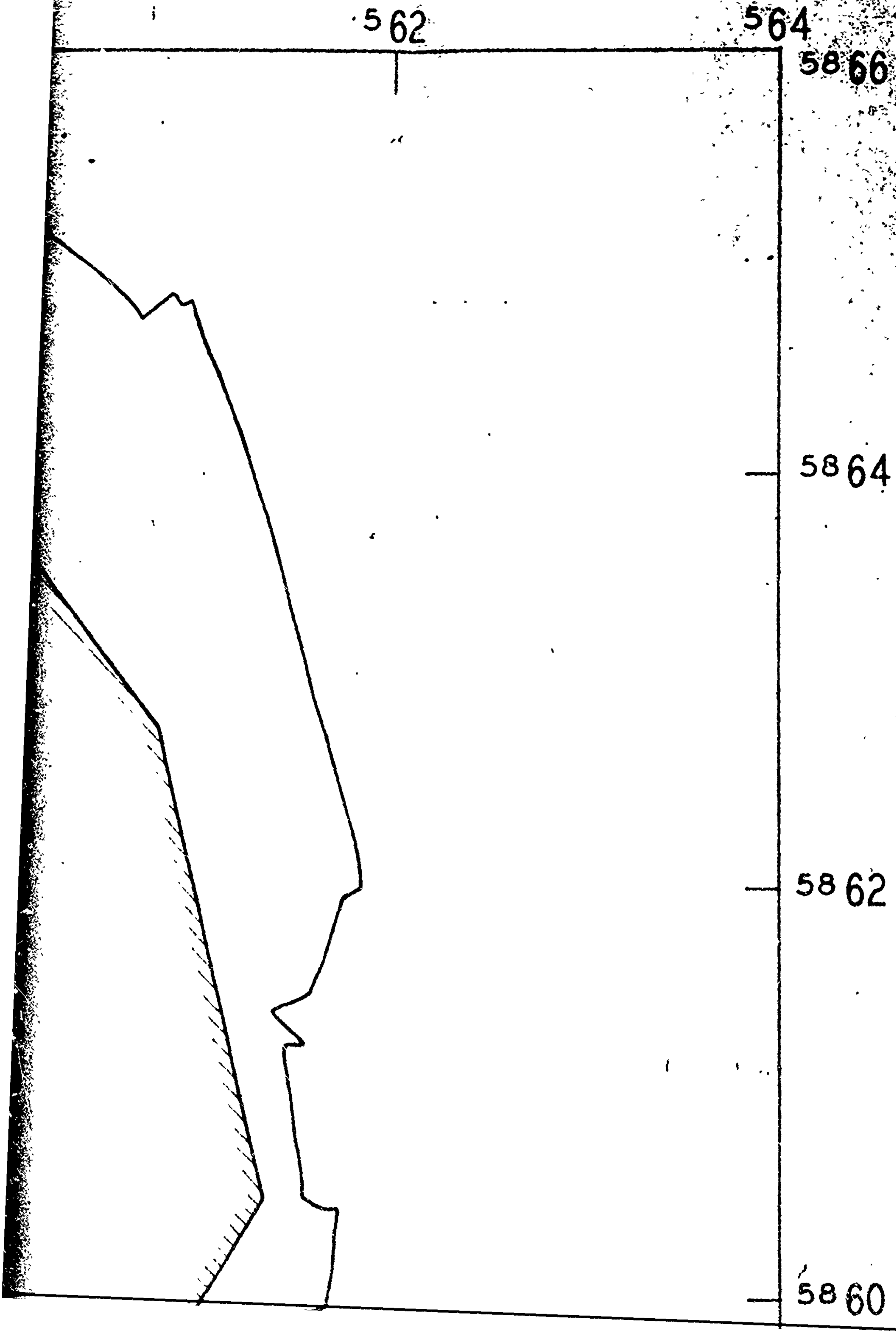
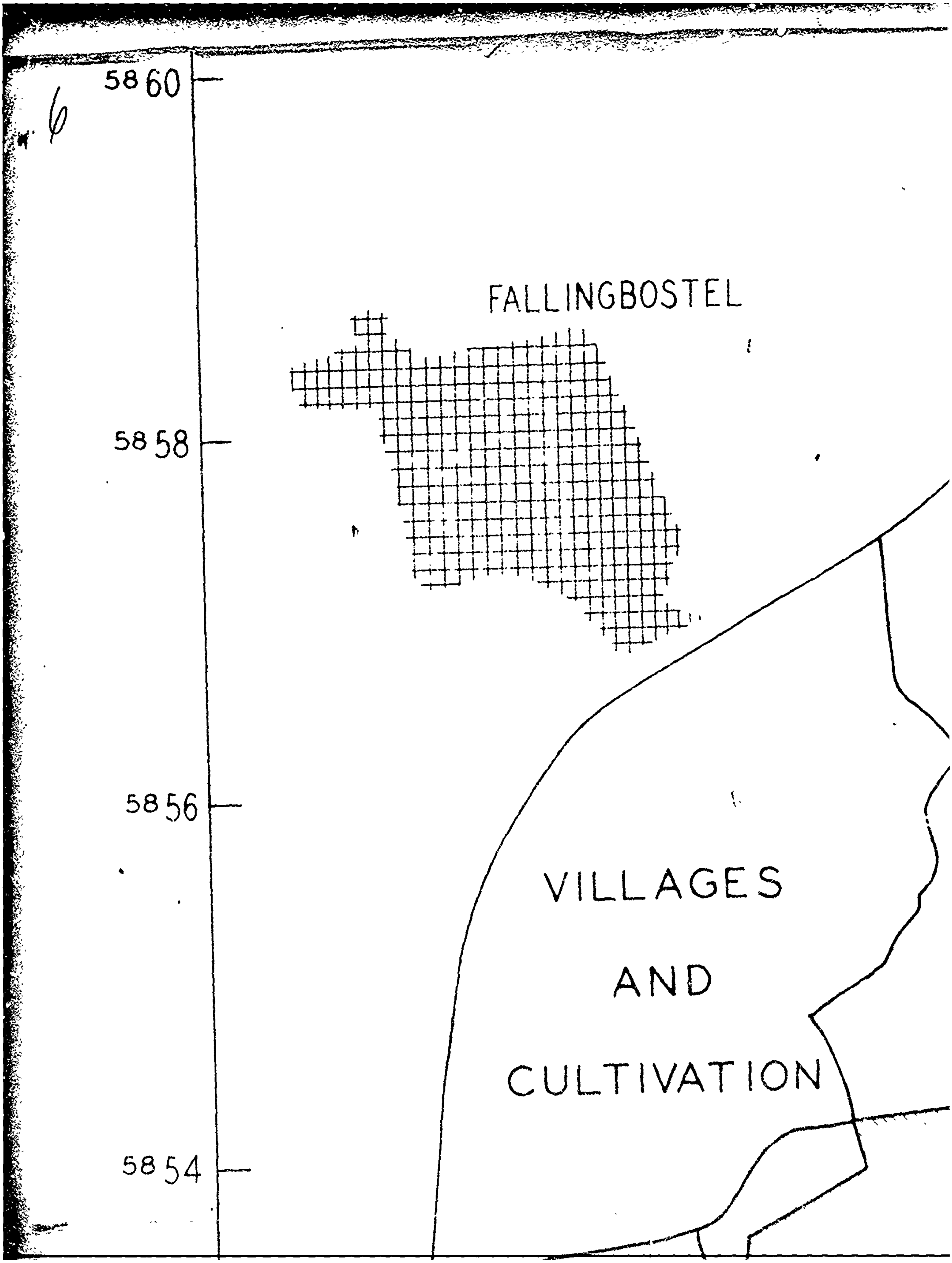
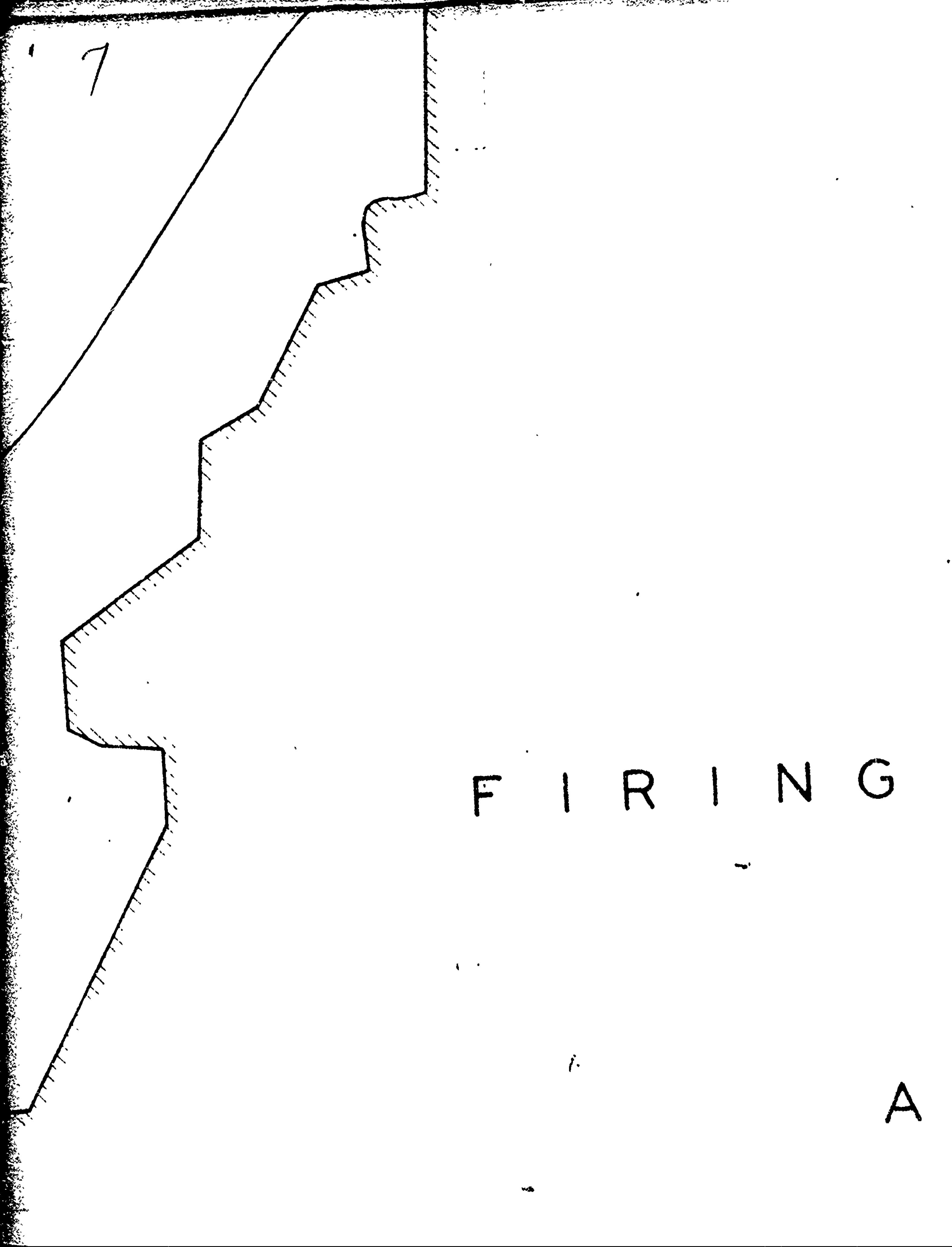
SERIES 841-TR-Z 29



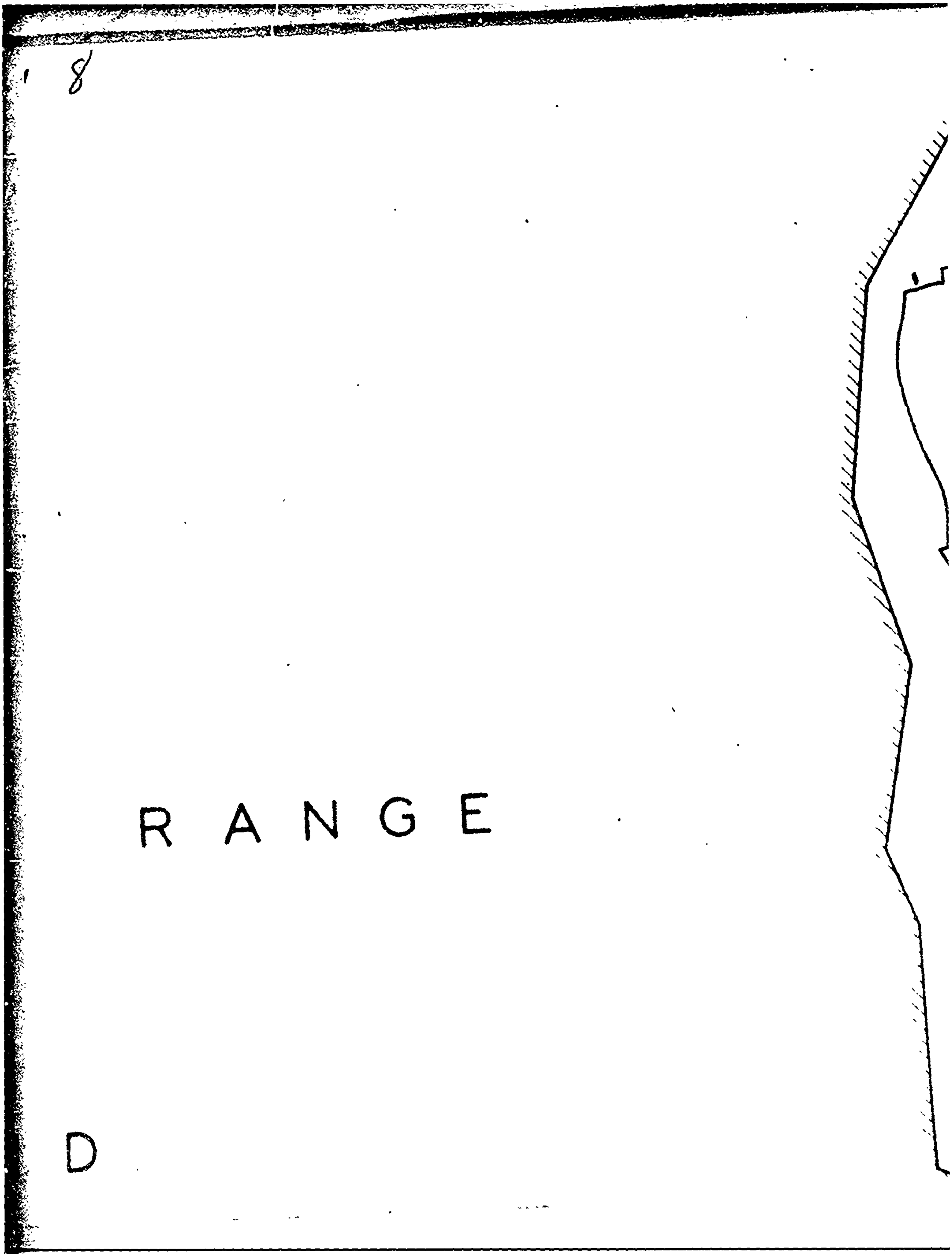
LEGEND

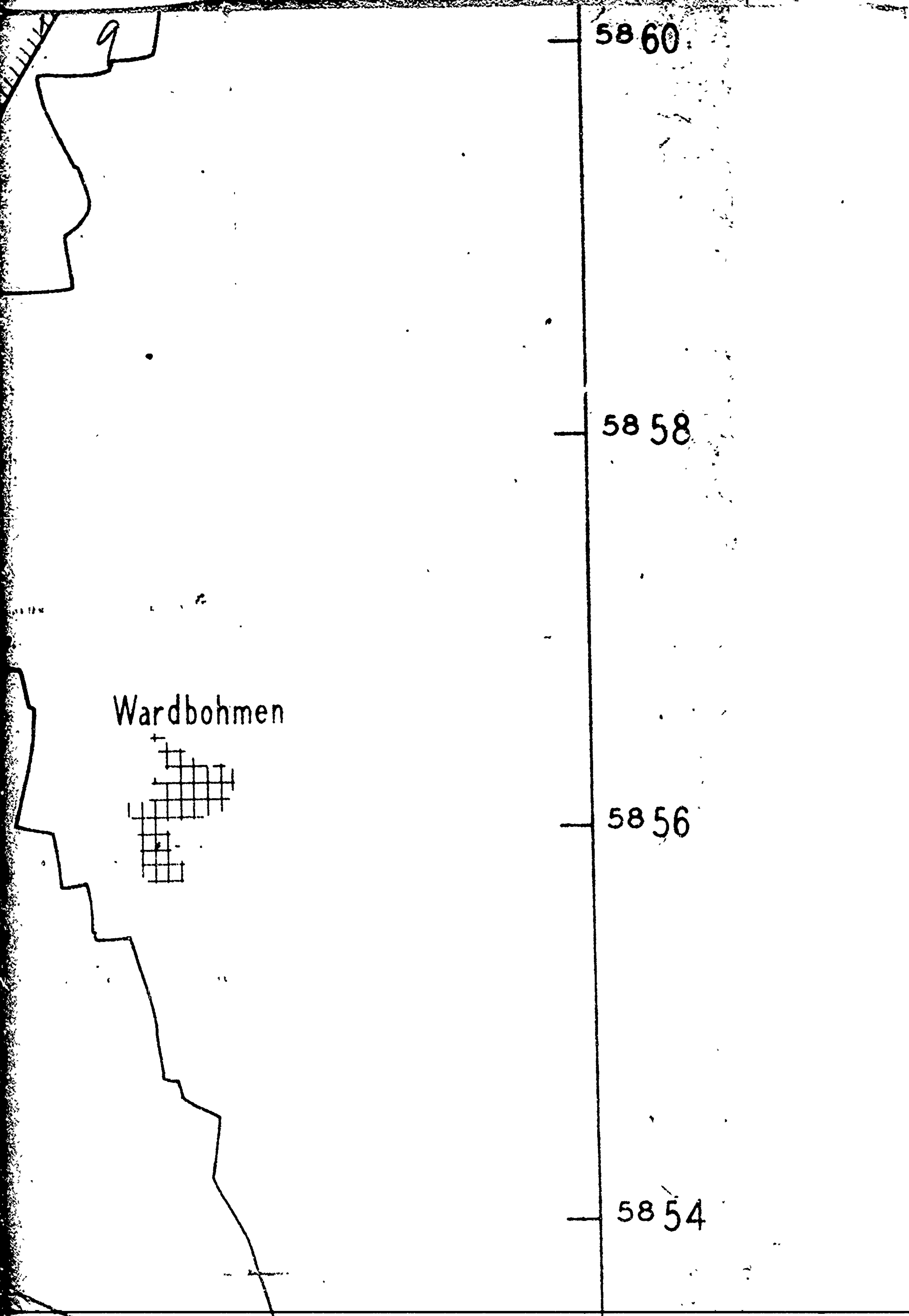
Map Unit	Hydrologic Geometry: West Bank SA	West Bank IA	West Bank SH	West Bank PS	East Bank SA	East Bank IA	East Bank SH	East Bank PS	Stream Width	Stream Depth	Surface Composition	Vegetation: Spacing of stems > the specified diameter, in 1.0	2.5	4.0	5.5	7.0	8.5	10.0	Visibility
1	1	4	3		1	3	4		2	1	3S	7	7	7	7	7	7	7	7
2	1	5	7		1	7	8		1	1	6M	1	1	2	2	4	6	7	2
3	1	5	7		1	7	8		1	1	6M	1	2	7	7	7	7	7	3
4	1	5	7		1	7	8		1	1	6M	2	2	2	2	2	5	7	7
5	1	5	7		1	7	8		1	1	6M	4	4	4	4	4	4	5	4
6	1	5	7		1	7	8		1	1	6M	7	7	7	7	7	7	7	7
7	1	6	8		1	6	8		1	1	6M	3	3	3	4	4	7	7	7
8	1	6	8		1	6	8		1	1	6M	7	7	7	7	7	7	7	7
9	1	6	8		2	9	8		1	1	6M	1	1	1	2	3	5	7	7
10	1	6	8		2	9	8		1	1	6M	3	3	3	3	3	3	4	7
11	1	6	8		2	9	8		1	1	6M	3	3	3	3	3	4	6	7
12	1	6	8		2	9	8		1	1	6M	4	4	4	4	4	4	4	7
13	1	6	8		2	9	8		1	1	6M	7	7	7	7	7	7	7	7
14	1	7	7		1	7	8		1	1	6M	2	2	2	2	3	4	5	7
15	1	7	7		1	7	8		1	1	6M	2	3	3	4	4	4	4	2
16	1	7	7		1	7	8		1	1	6M	7	7	7	7	7	7	7	7
17	1	7	8		1	6	8		1	1	6M	3	3	3	4	4	4	5	7
18	1	7	8		1	6	8		1	1	6M	4	4	4	4	4	4	4	7
19	1	7	8		1	6	8		1	1	6M	6	6	6	6	6	6	7	7
20	1	7	8		1	6	8		1	1	6M	7	7	7	7	7	7	7	7
21	1	8	8		1	9	8		1	1	6M	1	1	1	2	4	7	7	7
22	1	8	8		1	9	8		1	1	6M	1	2	2	2	4	5	7	7
23	1	8	8		1	9	8		1	1	6M	1	2	7	7	7	7	7	3
24	1	8	8		1	9	8		1	1	6M	2	2	2	2	3	4	5	7
25	1	8	8		1	9	8		1	1	6M	2	3	3	4	4	4	4	2
26	1	8	8		1	9	8		1	1	6M	3	3	3	3	3	3	4	7
27	1	8	8		1	9	8		1	1	6M	3	3	3	3	3	4	6	7
28	1	8	8		1	9	8		1	1	6M	3	3	3	4	4	4	5	7
29	1	8	8		1	9	8		1	1	6M	4	4	4	4	4	4	4	7
30	1	8	8		1	9	8		1	1	6M	6	6	6	6	6	6	7	7
31	1	8	8		1	9	8		1	1	6M	7	7	7	7	7	7	7	7
32	1	8	8		2	8	8		1	1	6M	2	2	2	2	3	4	5	7
33	1	8	8		2	8	8		1	1	6M	4	4	4	4	4	4	4	7
34	1	8	8		2	8	8		1	1	6M	4	4	4	4	4	4	5	4
35	1	8	8		2	8	8		1	1	6M	6	6	6	6	6	6	7	7
36	1	8	8		2	8	8		1	1	6M	7	7	7	7	7	7	7	7
37	1	9	7		1	9	8		1	1	6M	2	2	2	3	3	6	7	7
38	1	9	7		1	9	8		1	1	6M	2	3	3	4	4	4	4	2
39	1	9	7		1	9	8		1	1	6M	3	3	3	3	3	3	4	7
40	1	9	7		1	9	8		1	1	6M	4	4	4	4	4	4	4	7
41	1	9	7		1	9	8		1	1	6M	7	7	7	7	7	7	7	7
42	1	9	8		1	10	8		3	1	6M	7	7	7	7	7	7	7	7
43	1	10	7		2	7	8		2	1	5M	1	2	2	2	4	5	7	7
44	1	10	7		2	7	8		2	1	5M	1	2	7	7	7	7	7	3
45	1	10	7		2	7	8		2	1	5M	2	3	3	4	4	4	4	2
46	1	10	7		2	7	8		2	1	5M	4	4	4	4	4	4	5	4
47	1	10	7		2	7	8		2	1	5M	7	7	7	7	7	7	7	7
48	1	10	8		2	10	8		1	1	4M	7	7	7	7	7	7	7	7
49	1	10	8		2	10	8		2	1	6M	4	4	4	4	4	4	5	4
50	1	10	8		1	6	8		2	1	6M	1	1	1	2	3	5	7	7
51	1	10	8		1	6	8		2	1	6M	2	2	2	2	2	2	2	7
52	1	10	8		1	6	8		2	1	6M	2	2	2	2	3	4	5	7
53	1	10	8		1	6	8		2	1	6M	4	4	4	4	4	4	5	4
54	1	10	8		1	6	8		[illegible]	1	6M	7	7	7	7	7	7	7	7
55	1	10	8		1	9	8		1	1	6M	1	1	2	2	4	6	7	2
56	1	10	8		1	9	[illegible]		1	1	6M	2	2	2	2	3	4	5	7
57	1	10	8		1	9	8		1	1	6M	2	3	3	4	4	4	5	3
58	1	10	8		1	9	8		1	1	6M	6	6	6	6	6	6	7	7
59	1	10	8		1	9	8		1	1	6M	7	7	7	7	7	7	7	7
60	1	10	8		1	9	8		2	1	6M	7	7	7	7	7	7	7	7
[illegible]	1	10	8		2	10	8		2	[illegible]	6M	1	1	2	2	4	6	7	2


6
58 60
58 58
58 56
58 54
FALLINGBOSTEL
VILLAGES
AND
CULTIVATION


7
FIRING
A

8





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59	1	10
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61	1	10
62	1	10
63	1	10
64	1	10
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66	2	3
67	2	4
68	2	5
69	2	8
70	2	8
71	2	8
72	2	8
73	2	8
74	2	8
75	2	8
76	2	8
77	2	[illegible]
78	2	[illegible]
79	2	[illegible]
80	2	[illegible]
81	2	[illegible]
82	2	[illegible]
83	2	[illegible]
84	2	[illegible]
85	2	[illegible]
86	2	[illegible]
87	2	[illegible]
88	2	[illegible]
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90	2	
91	2	
92	2	
93	2	
94	2	
95	2	
96	2	
97	2	
98	2	1
99	3	
100	3	
101	3	
102	3	
103	3	
104	3	1
105	4	
106	5	1
107	5	1
108	5	1
109	5	1
110	5	1
111	5	1

Map[††] Unit	E: A
112	
113	
114	
115	
116	
117	
118	
119	

57	1	10	8		1	9	8		1	1	6M	2	3	3	4	4	4	5	5
58	1	10	8		1	9	8		1	1	6M	6	6	6	6	6	6	7	7
59	1	10	8		1	9	8		1	1	6M	7	7	7	7	7	7	7	7
60	1	10	8		1	9	8		2	1	6M	7	7	7	7	7	7	7	7
61	1	10	8		2	10	8		2	1	6M	1	1	2	2	4	6	7	2
62	1	10	8		2	10	8		2	1	6M	1	2	7	7	7	7	7	3
63	1	10	8		2	10	8		2	1	6M	2	2	2	2	3	5	7	7
64	1	10	8		2	10	8		2	1	6M	7	7	7	7	7	7	7	7
65	2	1	8		2	2	8		7	1	7	7	7	7	7	7	7	7	7
66	2	3	x	x	1	1	x	x	7	2	5M	7	7	7	7	7	7	7	7
67	2	4	x	x	3	1	x	y	7	2	6	1	1	2	2	4	6	7	2
68	2	5	8		1	6	8		1	1	6M	7	7	7	7	7	7	7	7
69	2	8	8		1	10	8		1	1	6M	1	1	1	2	3	5	7	7
70	2	8	8		1	10	8		1	1	6M	1	2	7	7	7	7	7	3
71	2	8	8		1	10	8		1	1	6M	1	3	7	7	7	7	7	2
72	2	8	8		1	10	8		1	1	6M	2	2	2	2	2	3	3	7
73	2	8	8		1	10	8		1	1	6M	2	2	2	2	2	5	7	7
74	2	8	8		1	10	8		1	1	6M	2	2	2	2	3	4	5	7
75	2	8	8		1	10	8		1	1	6M	2	2	2	2	3	5	7	7
76	2	8	8		1	10	8		1	1	6M	2	3	3	4	4	4	4	2
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81	2	8	8		1	10	8		1	1	6M	3	3	3	4	4	4	5	7
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83	2	8	8		1	10	8		1	1	6M	7	7	7	7	7	7	7	7
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88	2	8	8		3	9	8		3	1	6M	2	3	3	4	4	4	4	2
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90	2	8	8		3	9	8		3	1	6M	7	7	7	7	7	7	7	7
91	2	9	8		1	10	7		1	1	6M	1	2	7	7	7	7	7	3
92	2	9	8		1	10	7		1	1	6M	2	2	2	2	2	3	3	7
93	2	9	8		1	10	7		1	1	6M	2	3	3	4	4	4	5	3
94	2	9	8		1	10	7		1	1	6M	3	3	3	3	3	4	6	7
95	2	9	8		1	10	7		1	1	6M	4	4	4	4	4	4	4	7
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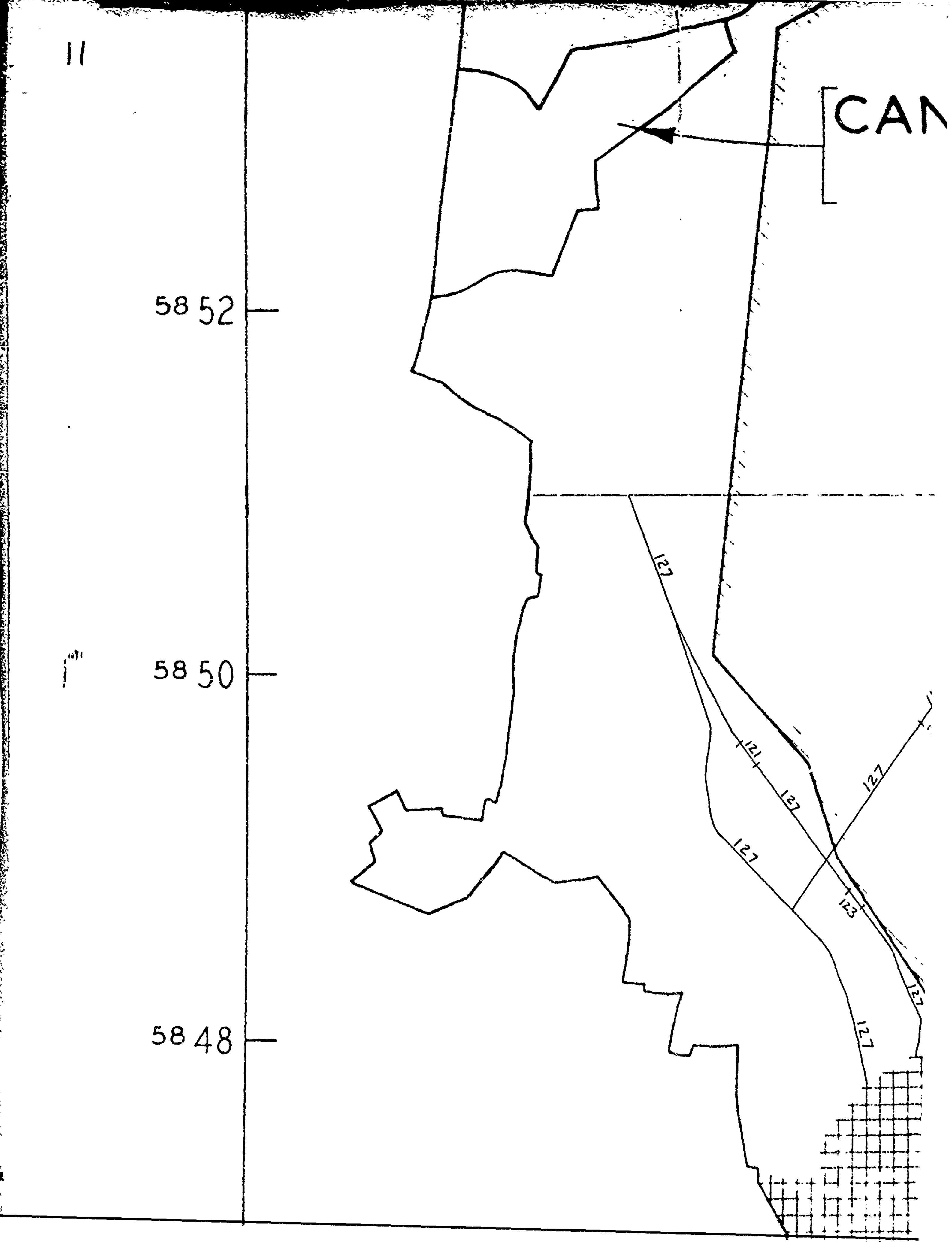
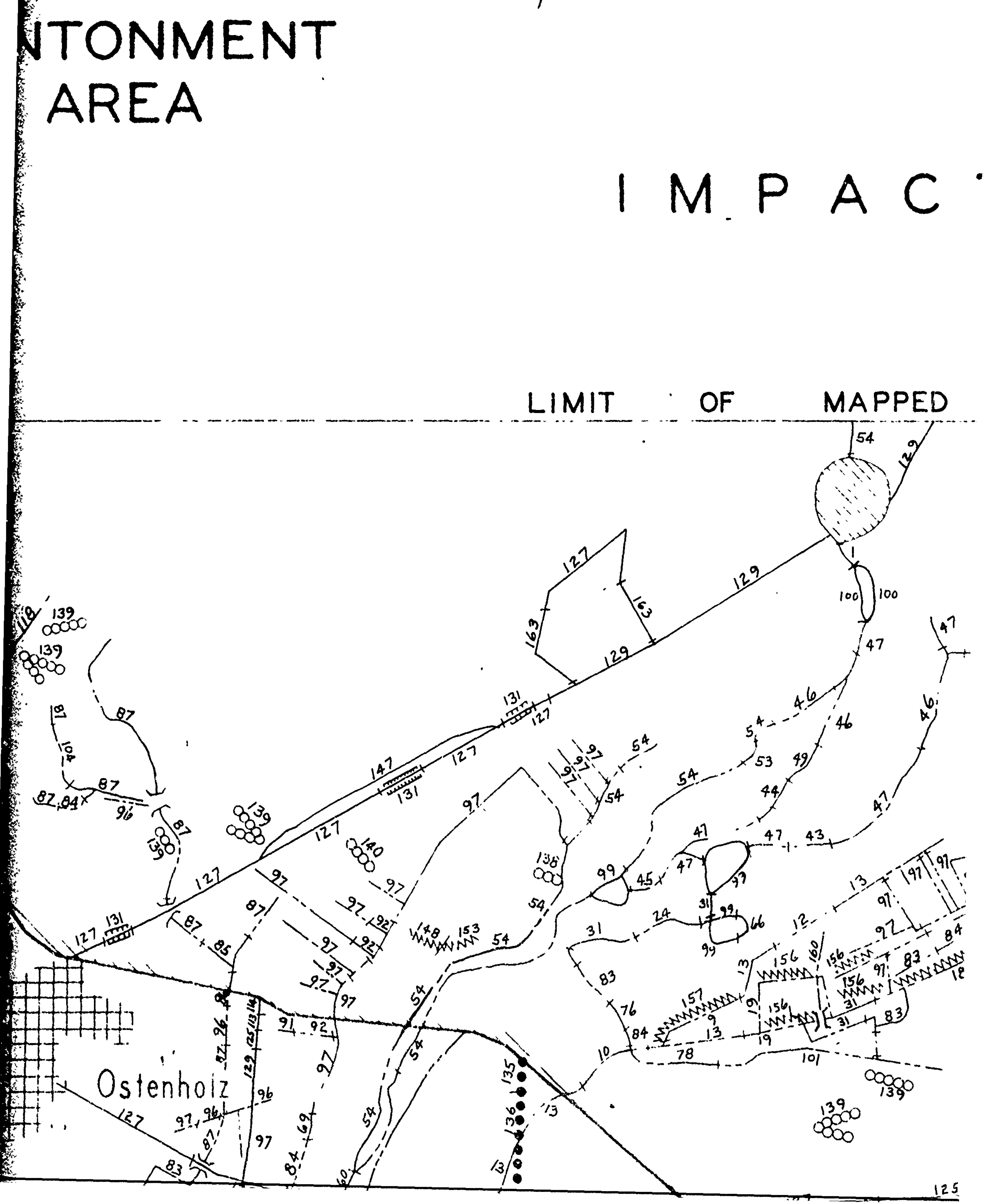
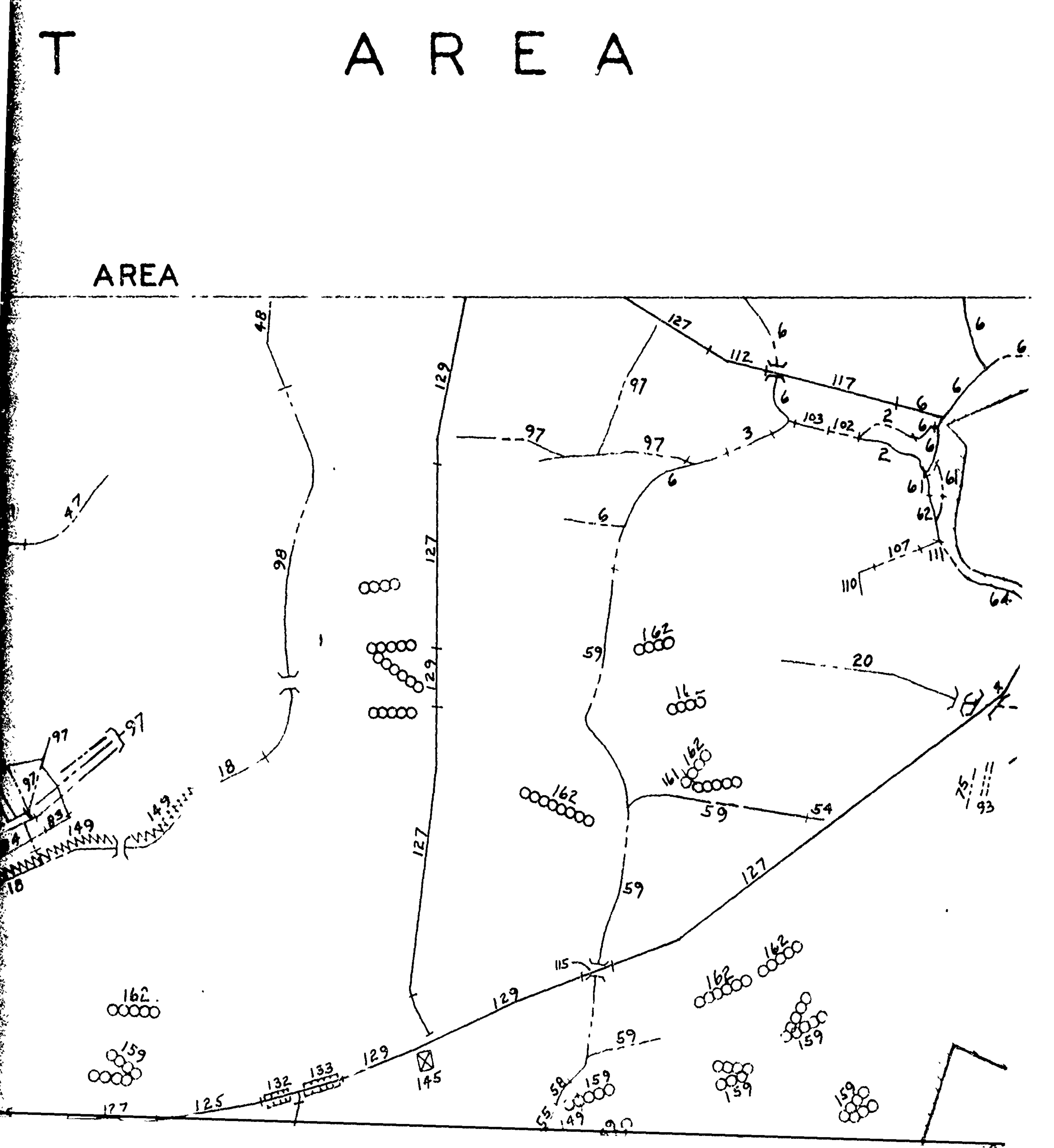
97	2	9	8		1	10	7		1	1	6M	7	7	7	7	7	7	7	7
98	2	10	8		1	9	8		1	1	6M	7	7	7	7	7	7	7	7
99	3	1	x	x	1	2	x	x	7	2	4S	7	7	7	7	7	7	7	7
100	3	3	5	5	3	2	3	4	7	2	4S	7	7	7	7	7	7	7	7
101	3	7	8		3	10	8		1	1	5M	2	2	2	2	2	3	3	7
102	3	9	8		1	10	7		3	1	5M	2	2	2	2	2	3	3	7
103	3	9	8		1	10	7		3	1	5M	7	7	7	7	7	7	7	7
104	3	10	8	2	2	10	8		1	1	7	7	7	7	7	7	7	7	7
105	4	3	x	x	1	3	x	x	7	2	7	7	7	7	7	7	7	7	7
106	5	10	8		1	10	8		4	1	6M	2	2	2	2	3	4	5	7
107	5	10	8		1	10	8		4	1	6M	2	2	2	2	3	5	7	7
108	5	10	8		1	10	8		4	1	6M	2	2	2	3	3	6	7	7
109	5	10	8		1	10	8		4	1	6M	2	3	3	4	4	4	4	2
110	5	10	8		1	10	8		4	1	6M	6	6	6	6	6	6	7	7
111	5	10	8		1	10	8		4	1	6M	7	7	7	7	7	7	7	7

Map Unit[††]	SURFACE GEOMETRY Exterior Angle	Interior Angle	Step Height	SURFACE COMPOSITION	VEGETATION Spacing of Stems > the Specified Diameter, in. 1.0	2.5	4.0	5.5	7.0	8.5	10.0	Visibility
112	1/1	6/6	5/5	3S	4	4	4	4	4	4	4	7
113	1/1	6/6	5/5	6M	2	2	2	2	2	3	3	7
114	1/1	6/6	5/5	6M	6	6	6	6	6	6	7	7
115	1/1	6/6	5/5	6M	7	7	7	7	7	7	7	7
116	1/1	6/6	5/5	7	1	1	1	2	3	5	7	7
117	1/1	6/6	5/5	7	1	1	2	2	4	6	7	2
118	1/1	6/6	5/5	7	1	2	2	2	3	7	7	7
119	1/1	6/6	5/5	7	2	2	2	2	3	4	5	7
120	1/1	6/6	5/5	7	2	2	2	3	3	6	7	7


CAN
58 52
58 50
58 48
127
121
127
127
127
123
127
127



NTONMENT
AREA
IMPACT
LIMIT OF MAPPED
Ostenholz


T AREA
AREA
48
98
18
149
47
97
83
129
127
6
112
117
103
102
2
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61
62
107
111
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162
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75
93
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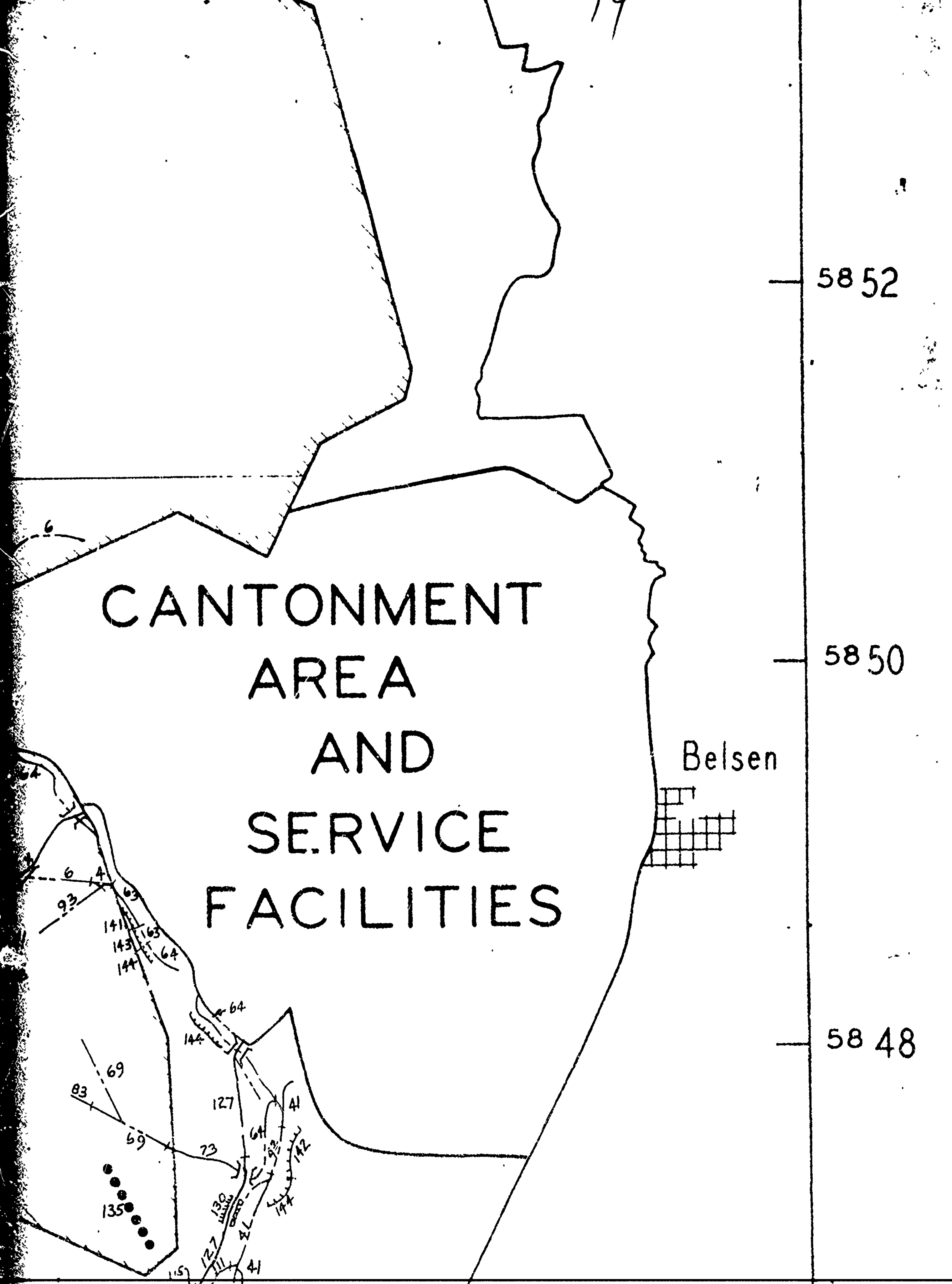
125
132
133
145
159
58
55

14


CANTONMENT
AREA
AND
SERVICE
FACILITIES
Belsen
58 52
58 50
58 48
6
4
63
93
141
143
144
163
64
69
83
59
73
127
41
142
135
130
111
115

119	1/1	6/6	5/5	7	2	2	2	2	3	4	5	7
120	1/1	6/6	5/5	7	2	2	2	3	3	6	7	7
121	1/1	6/6	5/5	7	2	3	3	3	4	4	5	7
122	1/1	6/6	5/5	7	3	3	3	3	3	3	4	7
123	1/1	6/6	5/5	7	3	3	3	3	3	4	6	7
124	1/1	6/6	5/5	7	3	3	3	4	4	7	7	7
125	1/1	6/6	5/5	7	4	4	4	4	4	4	4	7
126	1/1	6/6	5/5	7	6	6	6	6	6	6	7	7
127	1/1	6/6	5/5	7	7	7	7	7	7	7	7	7
128	1/1	6/6	5/5	7S	2	2	2	2	2	3	3	7
129	1/1	6/6	5/5	7S	7	7	7	7	7	7	7	7
130	1/1	7/7	8/8	6M	7	7	7	7	7	7	7	7
131	1/1	7/7	8/8	7	7	7	7	7	7	7	7	7
132	1/1	7/7	8/8	7S	4	4	4	4	4	4	4	7
133	1/1	7/7	8/8	7S	7	7	7	7	7	7	7	7
134	1/1	8/8	8/8	6M	7	7	7	7	7	7	7	7
135	1/1	8/8	8/8	7	2	2	2	2	2	5	7	7
136	1/1	8/8	8/8	7S	7	7	7	7	7	7	7	7
137	1/1	9/9	8/8	7	1	3	7	7	7	7	7	2
138	1/4	10/9	8/7	3M	7	7	7	7	7	7	7	7
139	1/4	10/9	8/7	7	7	7	7	7	7	7	7	7
140	1/4	10/9	8/7	7S	7	7	7	7	7	7	7	7
141	2/1	7/1	8/1	6M	2	2	2	2	3	5	7	7
142	2/1	7/1	8/1	6M	7	7	7	7	7	7	7	7
143	2/1	7/1	8/1	7	2	2	2	2	3	5	7	7
144	2/1	7/1	8/1	7	7	7	7	7	7	7	7	7
145	2/2	10/10	8/8	7S	7	7	7	7	7	7	7	7
146	3/2	3/3	1/3	7	7	7	7	7	7	7	7	7
147	3/2	4/5	4/1	7	7	7	7	7	7	7	7	7
148	3/2	5/5	8/8	3M	7	7	7	7	7	7	7	7
149	3/2	5/5	8/8	4M	7	7	7	7	7	7	7	7
150	3/2	5/5	8/8	6	2	2	2	3	3	6	7	7
151	3/2	5/5	8/8	6M	1	2	2	2	4	5	7	7
152	3/2	5/5	8/8	6M	2	3	3	4	4	4	4	2
153	3/2	5/5	8/8	6M	7	7	7	7	7	7	7	7
154	3/2	5/5	8/8	7	2	2	2	3	3	6	7	7
155	3/2	5/5	8/8	7	2	3	3	4	4	4	5	3
156	3/2	5/5	8/8	7	7	7	7	7	7	7	7	7
157	3/2	5/5	8/8	7S	1	1	1	2	3	5	7	7
158	3/3	7/6	2/1	6M	7	7	7	7	7	7	7	7
159	3/3	7/6	2/1	7	7	7	7	7	7	7	7	7
160	5/5	10/10	7/7	7	7	7	7	7	7	7	7	7
161	5/6	10/5	2/3	6M	7	7	7	7	7	7	7	7
162	5/6	10/5	2/3	7	7	7	7	7	7	7	7	7
163	9/2	10/9	6/8	7	7	7	7	7	7	7	7	7

†Hydrologic geometry units 1 - 111 represent class ranges of approach angles (EA and IA, see Hydrologic Geomet Diagram below), step height SH, position of step base PS, referenced to water level, stream width SW, and st depth SD. The west bank is the first bank encountered while traversing an area in an easterly direction (i. azimuth >0 to 180 deg) and the east bank is the first bank encountered while traversing an area in a westerl ection (i.e. azimuth >180 to 360 deg), assuming that the vehicle intersects the feature at a right angle.

††Surface geometry units 112 - 163 represents class ranges of approach angles EA and IA, and step height SH (see Surface Geometry Diagram below). Fractional designations indicate that dual classes were mapped. The numera the fraction indicates class ranges that will be encountered while traversing an area in an easterly directi azimuth from >0 to 180 deg) and the denominator refers to a westerly direction (i.e. azimuth from >180 to 36 assuming that the vehicle intersects the feature at a right angle.

Class ranges for each factor are:

Hydrologic Geometry*

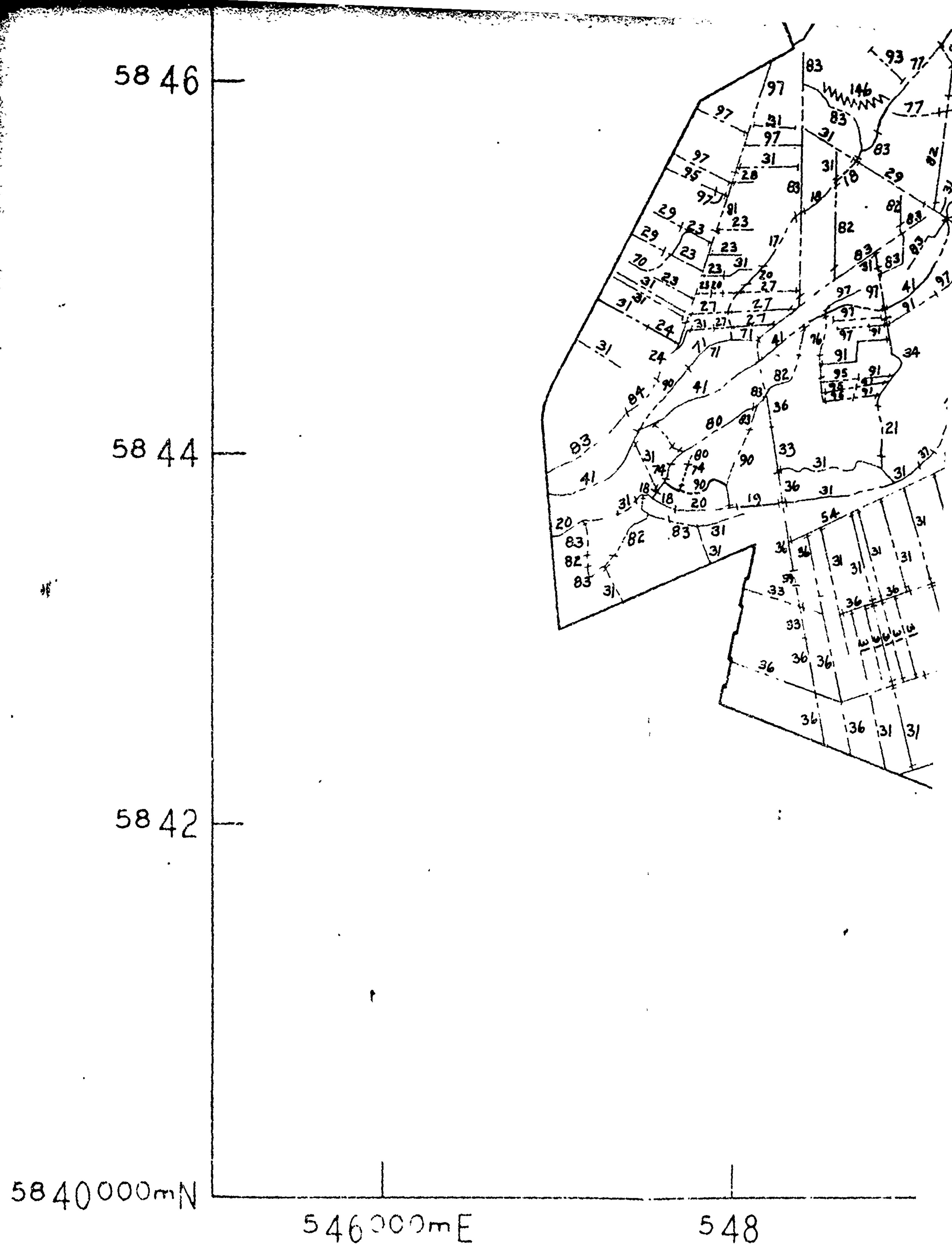
Approach Angle (EA-IA)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17

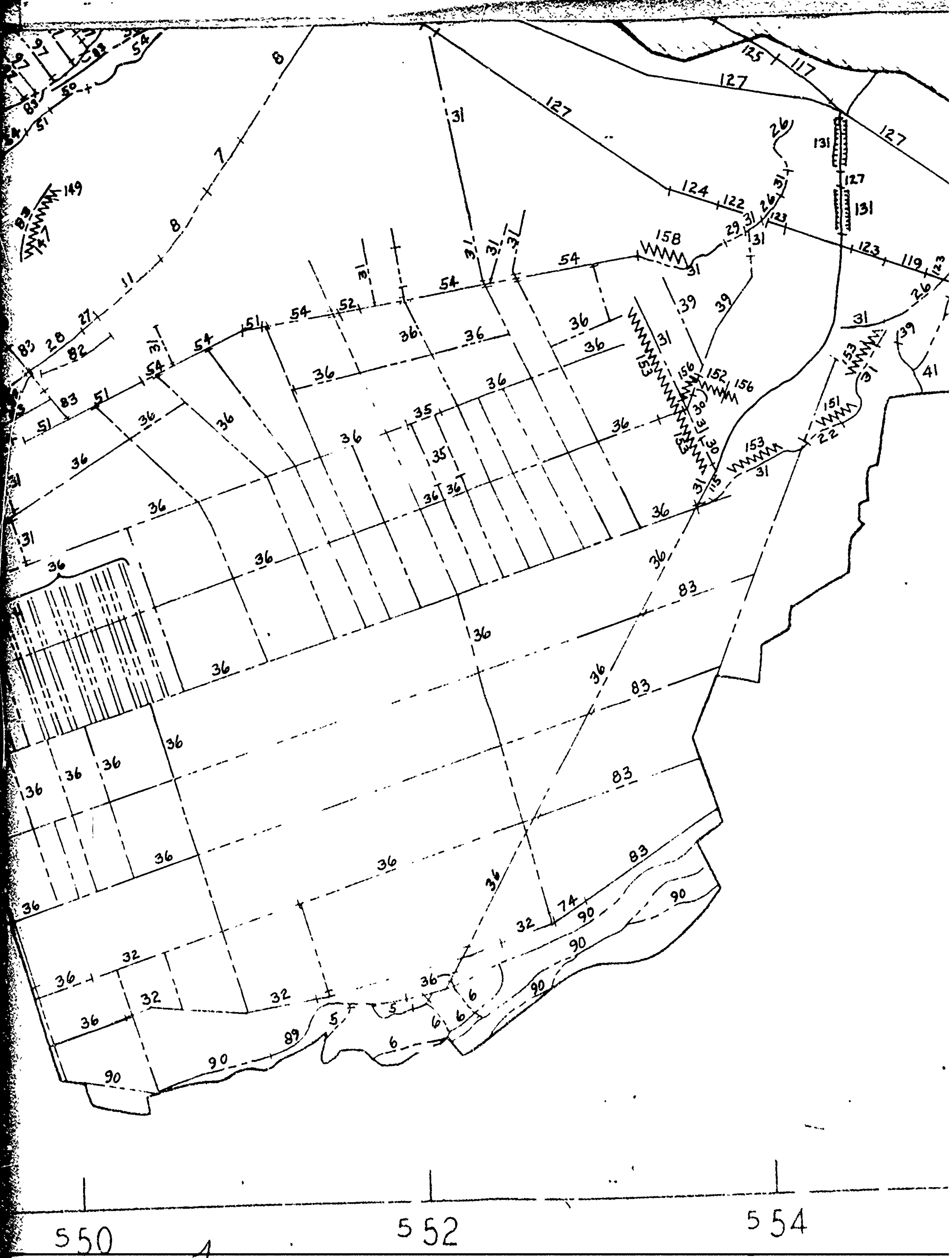
Step Height (SH)		
Map Class	Step Height (SH) in[1]	in[2]
1	<8	<12
2	8-10	12-24
3	>10-12	>24-36
4	>12-14	>36-48

Position of Step Base (PS)	
Map Class	in
1	>48
2	>36-48
3	>18-36 bwl[3]
4	1-18
5	at water level

Stream Width (SW)	
Map Class	ft
1	0-5
2	>5-10
3	>10-15
4	>15-20
5	>20-25

Stream Depth (SD	
Map Class	ft
1	<3
2	3-4.5
3	>4.5-15
4	>15


5846
5844
5842
5840000mN
546000mE
548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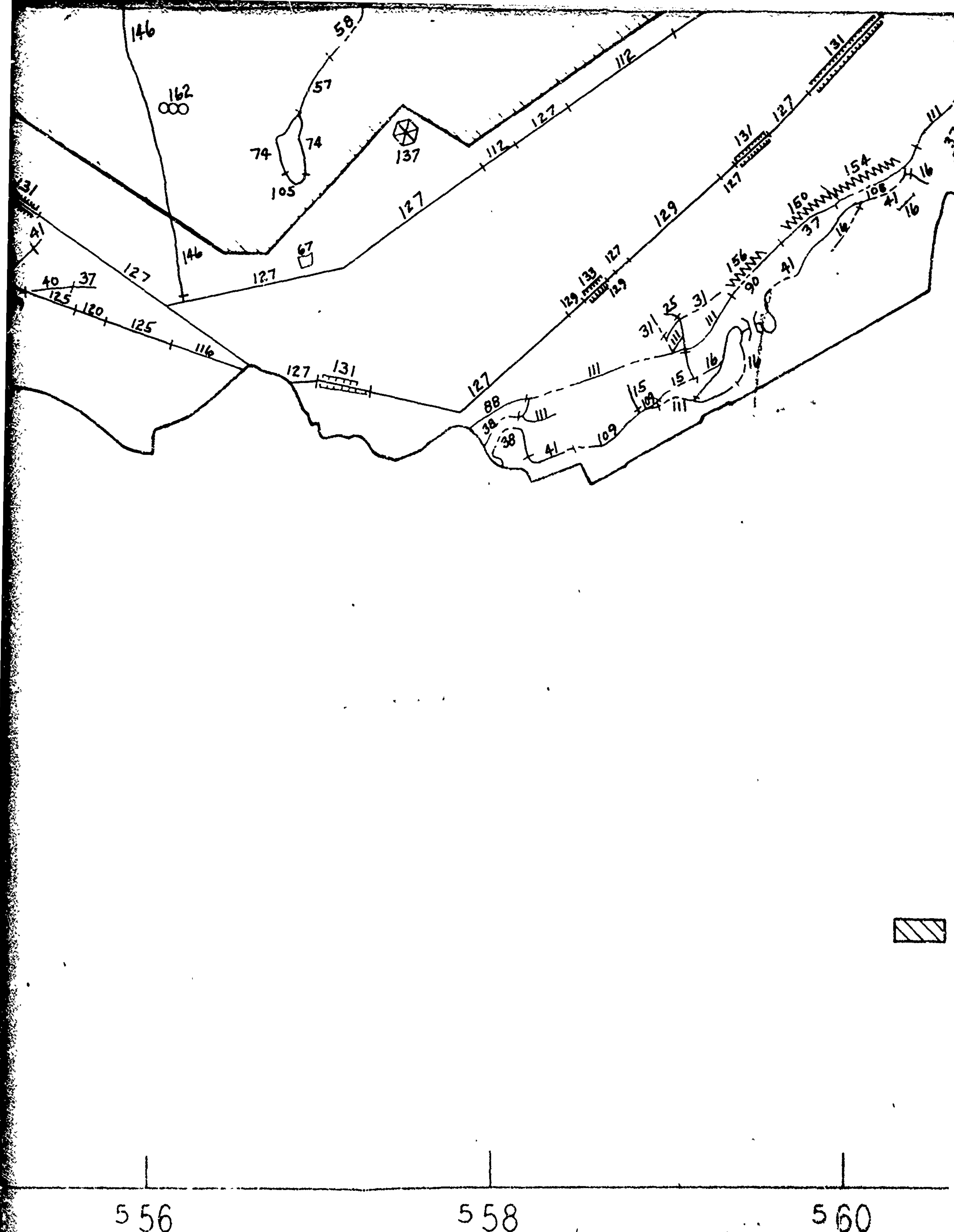
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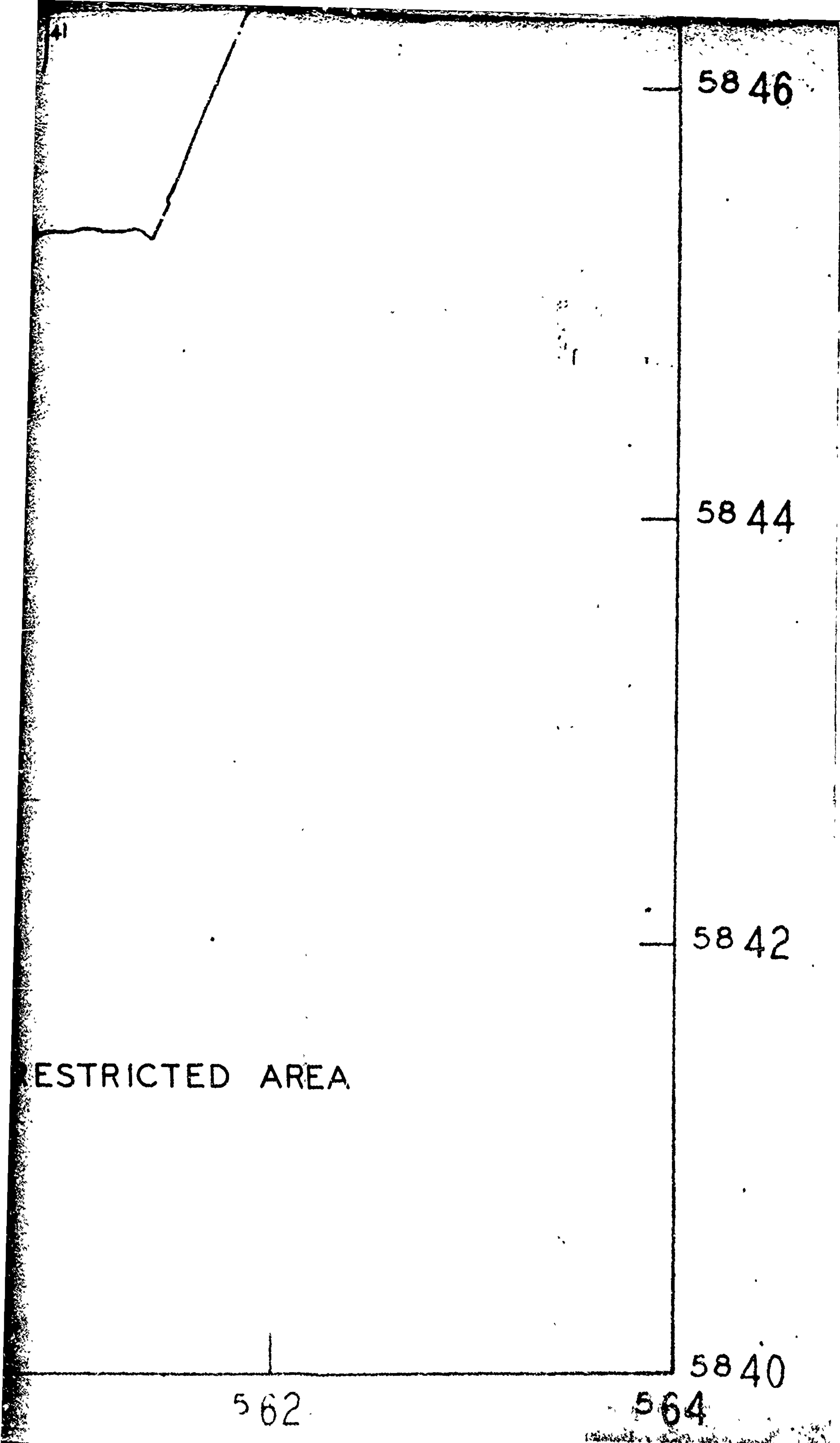
558
560

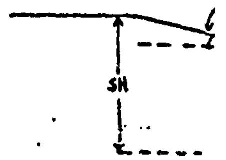


10 1945

1 step height class r
2 step height class r
3 below water level
4 above water level

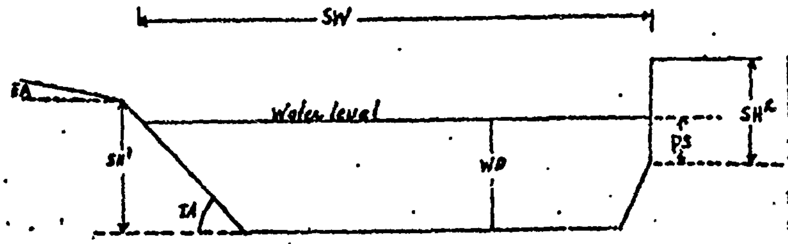
Sur

Approach Angle (F	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45



9	>36-45	x	absent	9	>48	
10	>45			x	absent	

step height class ranges used when water depth is <3 ft
step height class ranges used when water depth is ≥3 ft
below water level
above water level



Surface Geometry*

Approach Angle (EA-IA)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45

Step Height (SH)	
Map Class	in
1	<8
2	8-10
3	>10-12
4	>12-14
5	>14-16
6	>16-20
7	>20-30
8	>30

Surface Composition**

Map Class	6-12 in RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

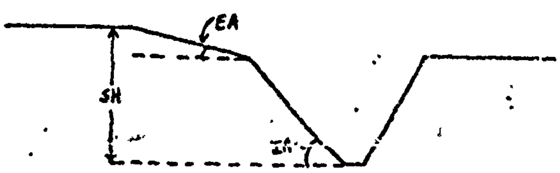
Map Class	0-6 in CI
1S	0-20
2S	>20-40
3S	>40-75
4S	>75-125
5S	>125-175
6S	>175-250
7S	>250

Map Class	6-12 in CI
1M	0-15
2M	>15-30
3M	>30-45
4M	>45-60
5M	>60-80
6M	>80

Vegetation***

Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

Visibility	
Map Class	ft
1	<15
2	15-21
3	>21-27
4	>27-33
5	>33-39
6	>39-45
7	>45



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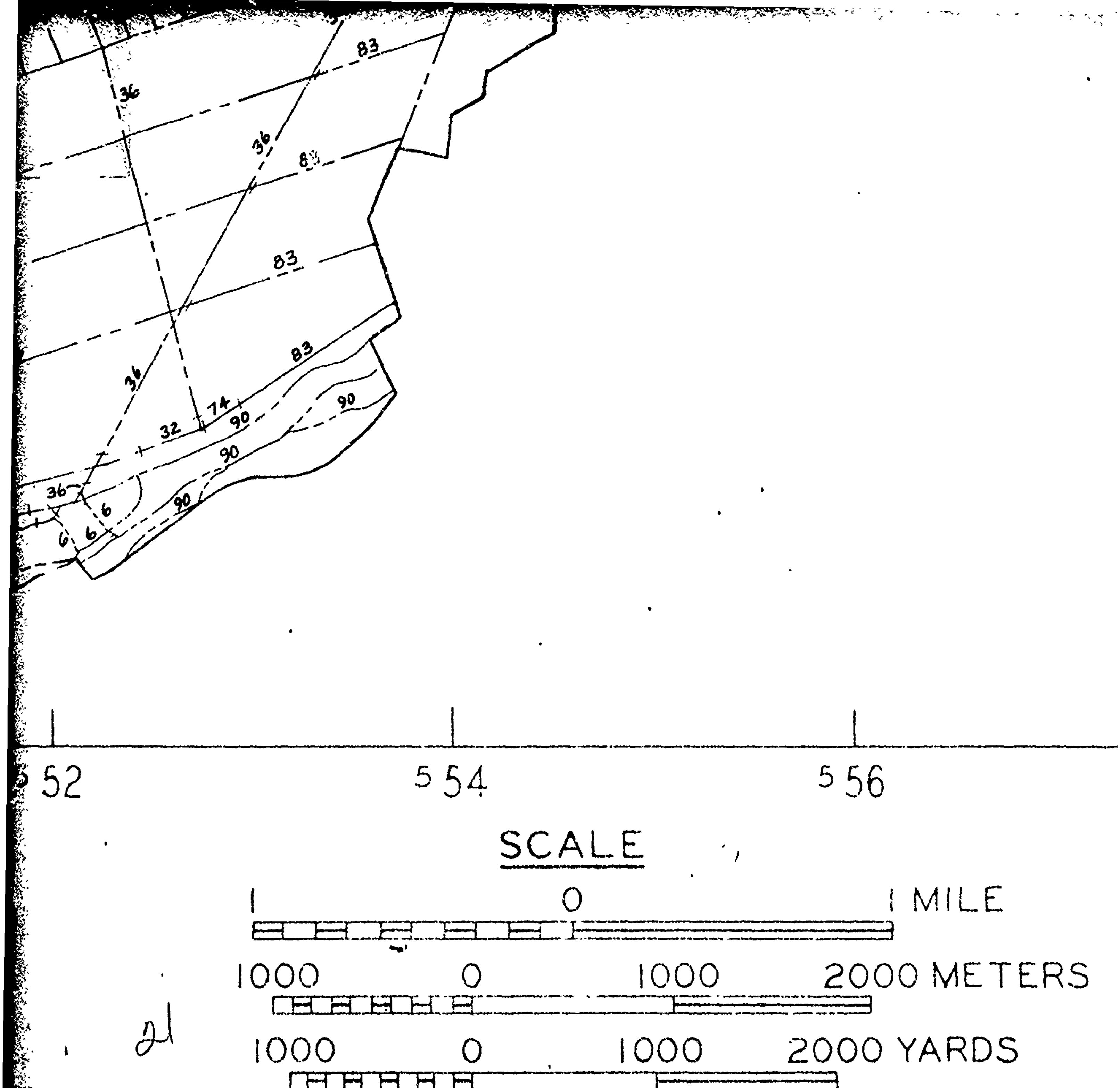
TERRAIN FACTOR COMPLEX MAP
WEST GERMANY


83
36
83
36
83
83
36
74
32
90
90
90
90
36
6
6
6
6
5 52
5 54
5 56
SCALE
1 0 1 MILE
1000 0 1000 2000 METERS
1000 0 1000 2000 YARDS

21

2	8-10
3	>10-12
4	>12-14
5	>14-16
6	>16-20
7	>20-30
8	>30

3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

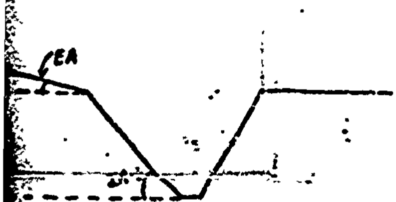
3S	>50-75
4S	>75-125
5S	>125-175
6S	>175-250
7S	>250

3M	>30-45
4M	>45-60
5M	>60-80
6M	>80

Vegetation ***

Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

Visibility	
Map Class	ft
1	<15
2	>15-21
3	>21-27
4	>27-33
5	>33-39
6	>39-45
7	>45



TERRAIN FACTOR COMPLEX MAP
WEST GERMANY

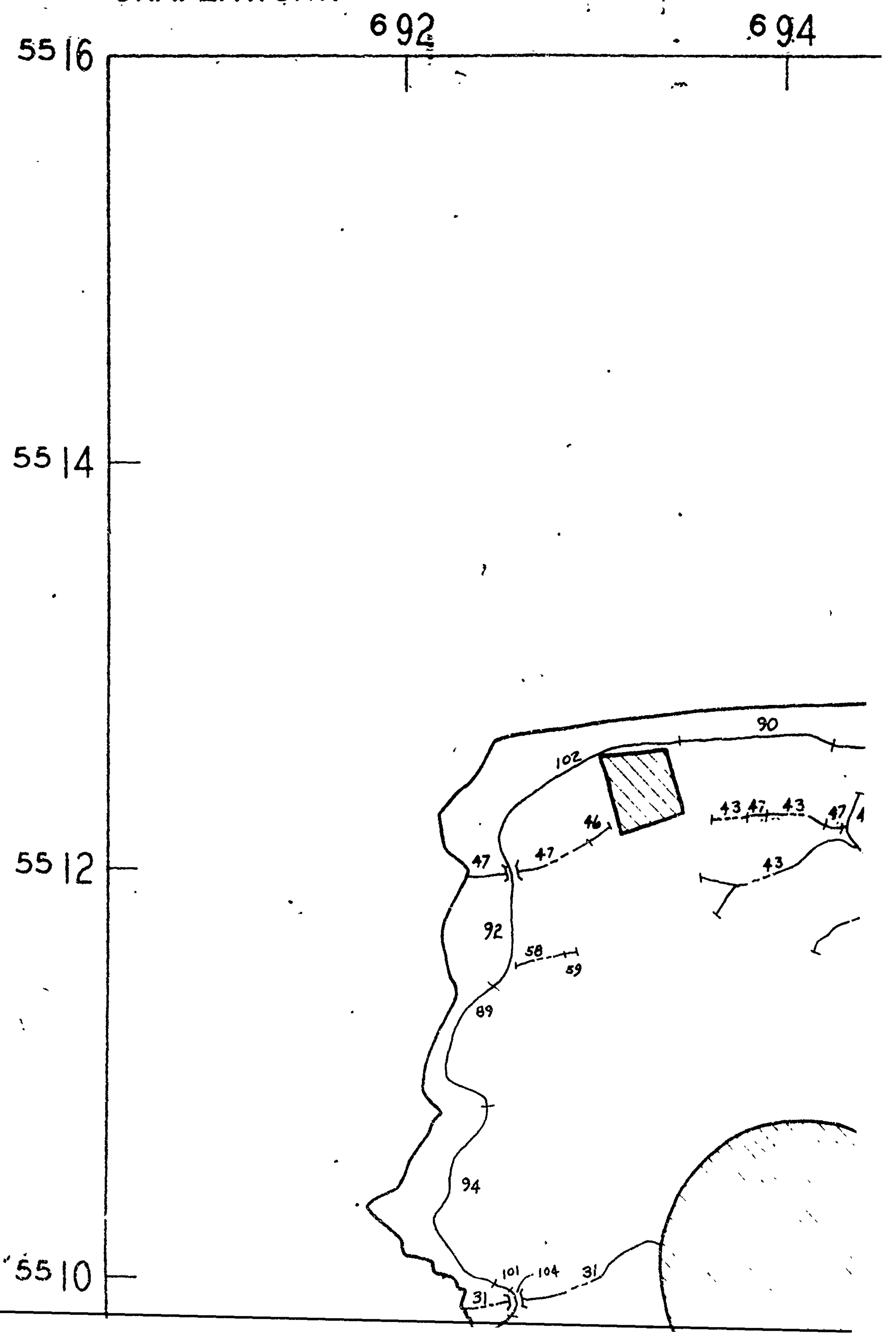
LINEAR FACTOR COMPLEXES
BERGEN-HOHNE

PLATE 5

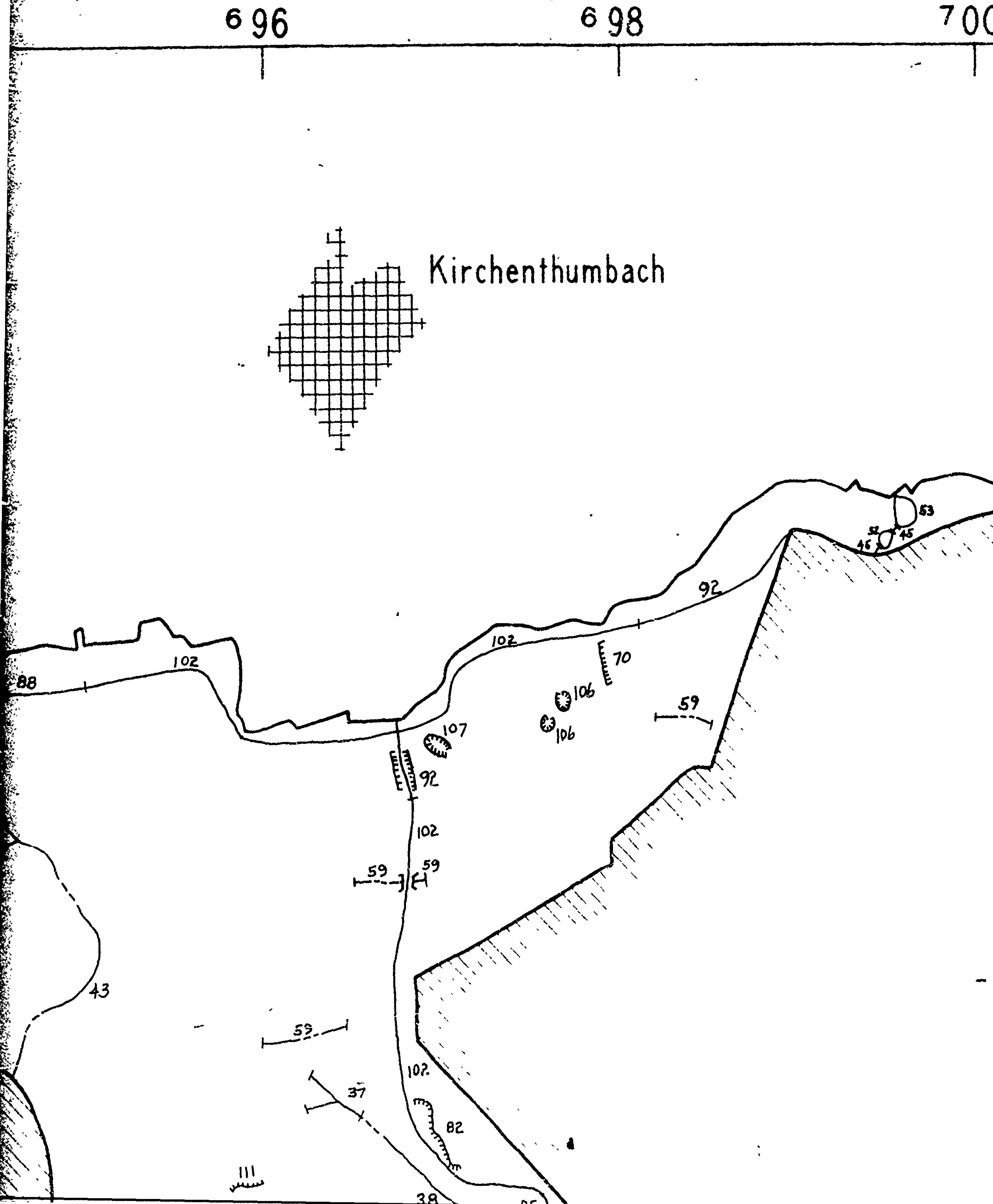
GRAFENWOHR

1

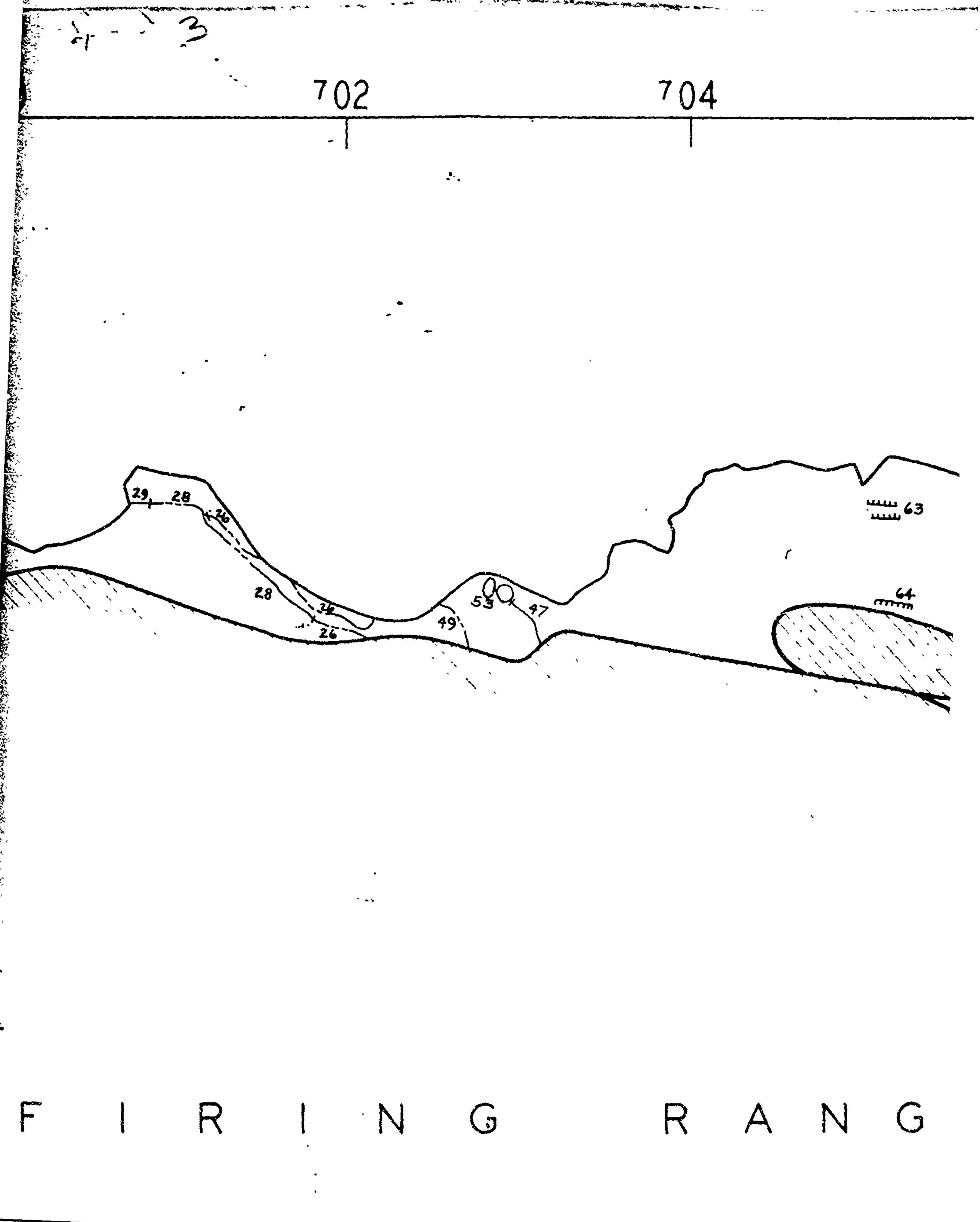
GRAFENWOHR



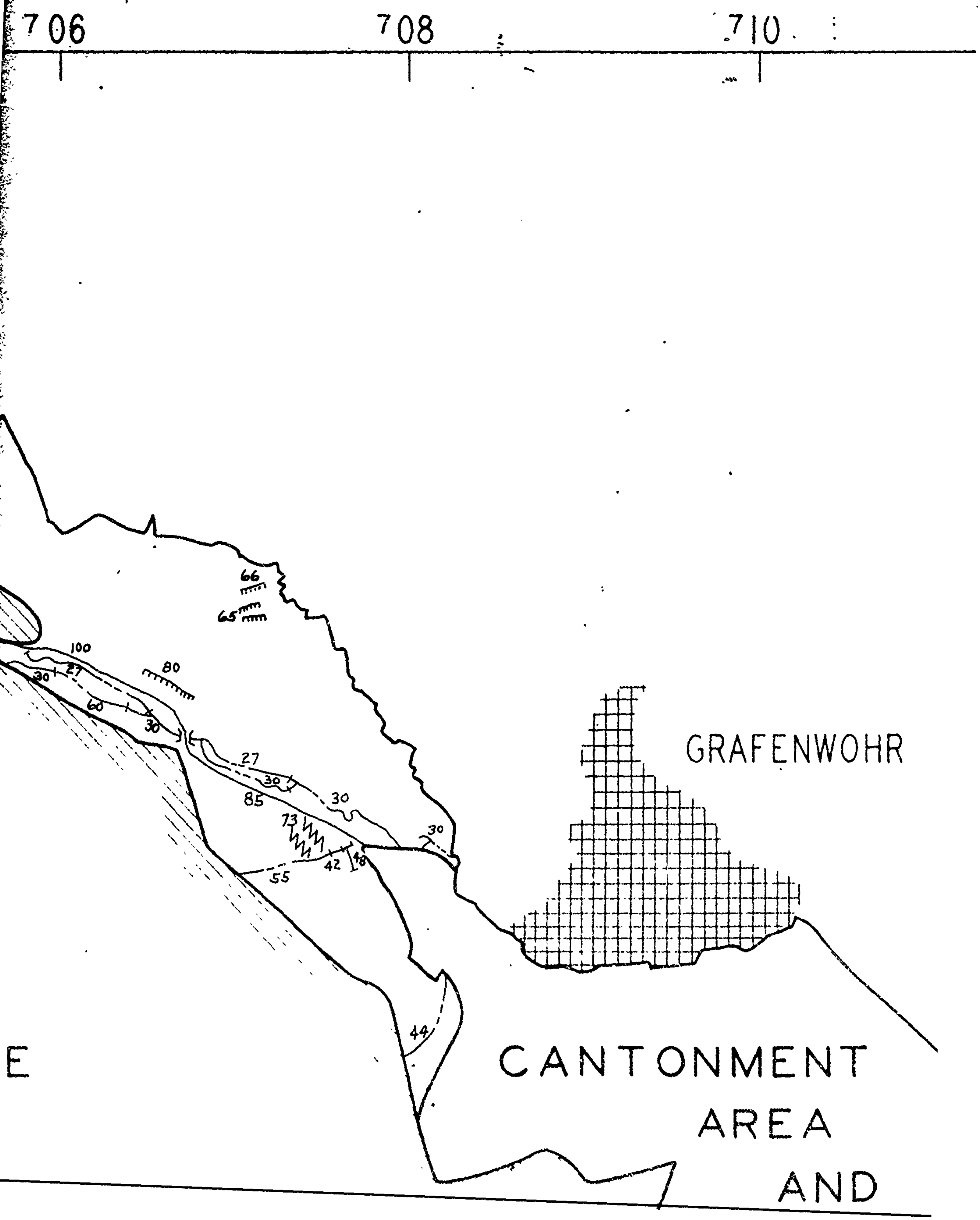
1 2

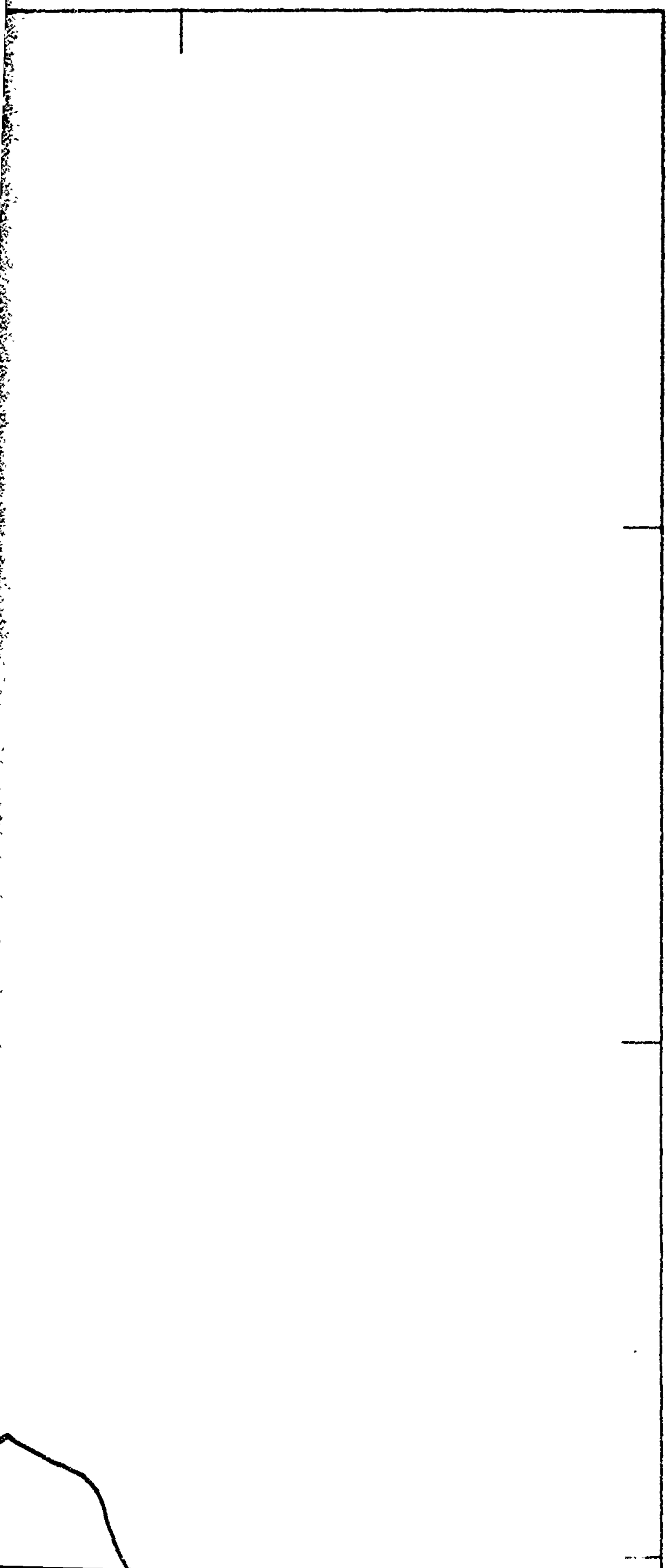


696
698
700
Kirchenthumbach
53
45
92
102
102
88
70
106
106
59
107
92
102
59
59
43
59
102
37
82
111
38


702
704
29
28
26
28
26
26
49
53
47
63
64
F I R I N G R A N G

4


706
708
710
66
65
100
80
27
30
60
30
27
30
85
30
73
30
55
42
48
44
GRAFENWOHR
E
CANTONMENT
AREA
AND



	HYDROLOGIC GEOMETRY								
	West Bank				East Bank				St
Map Unit	EA	IA	SH	PS	EA	IA	SH	PS	Width
1	1	4	4		1	9	3		2
2	1	4	8		2	5	8		1
3	1	4	8		1	5	8		1
4	1	5	8		1	5	8		1
5	1	5	8		1	5	8		1
6	1	5	8		1	5	8		1
7	1	5	8		1	5	8		1
8	1	5	8		1	5	8		1
9	1	5	8		1	5	8		1
10	1	6	8		1	7	8		1
11	1	6	8		1	7	8		1
12	1	6	8		2	5	8		5
13	1	7	8		1	6	7		2
14	1	7	8		1	6	7		2
15	1	8	4		1	3	4		5
16	1	8	8		2	8	8		1
17	1	8	8		2	8	8		1
18	1	8	8		3	10	7		1
19	1	8	8		3	10	7		1
20	1	8	8		3	10	7		1
21	1	9	7		1	9	8		1
22	1	10	7		1	10	4		1
23	1	10	7		1	10	4		1
24	1	10	7		1	10	7		1
25	1	10	8		1	9	8		2
26	1	10	8		1	10	8		2
27	1	10	8		1	10	8		2
28	1	10	8		1	10	8		[illegible]
29	1	10	8		1	10	8		[illegible]
30	1	10	8		1	10	8		[illegible]
31	1	10	8		2	9	8		[illegible]
32	1	10	8		3	10	8		[illegible]
33	1	10	8		9	1	8		[illegible]
34	2	2	8		10	3	8		
35	2	2	8		10	3	8		
36	2	4	8		1	4	8		
37	2	5	8		1	5	8		
38	2	5	8		1	5	8		
39	2	6	7		2	7	6		
40	2	6	8		1	8	8		
41	2	6	8		1	10	8		
42	2	9	8		2	9	8		
43	2	9	8		2	9	8		
44	2	9	8		2	9	8		
45	2	9	8		2	9	8		
46	2	9	8		2	9	8		
47	2	9	8		2	9	8		
48	2	10	7		2	10	8		
49	2	10	8		2	10	8		

6

RY		SURFACE COMPOSITION	VEGETATION							
Stream			Spacing of stems > the Specified diameter, in							
Width	Depth		1.0	2.5	4.0	5.5	7.0	8.5	10.0	Visibility
2	1	7S	7	7	7	7	7	7	7	7
1	1	4S	7	7	7	7	7	7	7	7
1	1	6M	2	2	2	2	2	2	3	7
1	1	6M	2	2	2	2	3	6	7	7
1	1	6M	2	2	2	2	4	7	7	7
1	1	6M	3	3	3	3	3	3	4	7
1	1	6M	3	3	4	4	4	5	5	4
1	1	6M	6	6	6	6	6	6	6	7
1	1	6M	7	7	7	7	7	7	7	7
1	1	6M	2	2	2	2	4	7	7	7
1	1	6M	3	3	3	3	3	3	4	7
5	1	6M	7	7	7	7	7	7	7	7
2	1	4M	7	7	7	7	7	7	7	1
2	1	4M	7	7	7	7	7	7	7	7
5	1	4M	7	7	7	7	7	7	7	7
1	1	3M	6	6	6	6	6	6	7	7
1	1	6M	7	7	7	7	7	7	7	7
1	1	3M	2	2	2	2	3	3	4	7
1	1	3M	2	2	2	2	4	7	7	7
1	1	3M	7	7	7	7	7	7	7	7
1	1	4M	7	7	7	7	7	7	7	1
1	1	5	6	6	6	6	6	6	7	7
1	1	5	7	7	7	7	7	7	7	7
1	1	4M	7	7	7	7	7	7	7	7
2	1	6M	2	2	2	2	2	4	6	7
2	1	6M	6	6	6	6	6	6	7	7
2	1	6M	7	7	7	7	7	7	7	7
3	1	6M	6	6	6	6	6	6	7	7
3	1	6M	7	7	7	7	7	7	7	7
[illegible]	1	4M	7	7	7	7	7	7	7	7
2	1	5S	7	7	7	7	7	7	7	7
1	1	4S	7	7	7	7	7	7	7	7
2	1	4M	7	7	7	7	7	7	7	7
7	1	4M	2	2	2	2	2	4	6	7
7	1	4	7	7	7	7	7	7	7	7
1	1	2S	7	7	7	7	7	7	7	7
1	1	6	7	7	7	7	7	7	7	7
1	1	6M	7	7	7	7	7	7	7	7
1	1	6M	2	2	2	2	4	7	7	7
2	1	2S	7	7	7	7	7	7	7	7
3	1	6M	7	7	7	7	7	7	7	7
1	1	6M	7	7	7	7	7	7	7	7
1	1	7	2	2	2	2	3	4	4	7
1	1	7	3	3	3	3	3	4	5	7
1	1	7	3	3	3	3	4	4	4	7
1	1	7	6	6	6	6	6	6	6	7
1	1	7	7	7	7	7	7	7	7	7
1	1	4M	7	7	7	7	7	7	7	7

LEGEND

†Hydrologic geometry units 1 - 62
Diagram below), step height SH, p
depth SD. The west bank is the f
azimuth >0 to 180 deg) and the ea
ection (i.e. azimuth >180 to 360

††Surface geometry units 63 - 111 re
Surface Geometry Diagram below).
the fraction indicates class rang
azimuth from >0 to 180 deg) and th
assuming that the vehicle interse

Class ranges for each factor are:

Approach Angle (FA-IA)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45

Step Heig	
Map Class	Step Heig in[1]
1	<8
2	8-1
3	>10-[illegible]
4	>12-14
5	>14-16
6	>16-20
7	> 20-30
8	> 30
x	

1 step height class ranges used
2 step height class ranges used
3 below water level
4 above water level

7

etry units 1 - 62 represent class ranges of approach angles (EA and IA, see Hydrologic Geometry , step height SH, position of step base PS, referenced to water level, stream width SW, and stream west bank is the first bank encountered while traversing an area in an easterly direction (i.e. 180 deg) and the east bank is the first bank encountered while traversing an area in a westerly dir- imuth >180 to 360 deg), assuming that the vehicle intersects the feature at a right angle.

y units 63 - 111 represents class ranges of approach angles EA and IA, and step height SH (see y Diagram below). Fractional designations indicate that dual classes were mapped. The numerator of dicates class ranges that will be encountered while traversing an area in an easterly direction (i.e. to 180 deg) and the denominator refers to a westerly direction (i.e. azimuth from >180 to 360 deg) he vehicle intersects the feature at a right angle.

r each factor are:

Hydrologic Geometry *

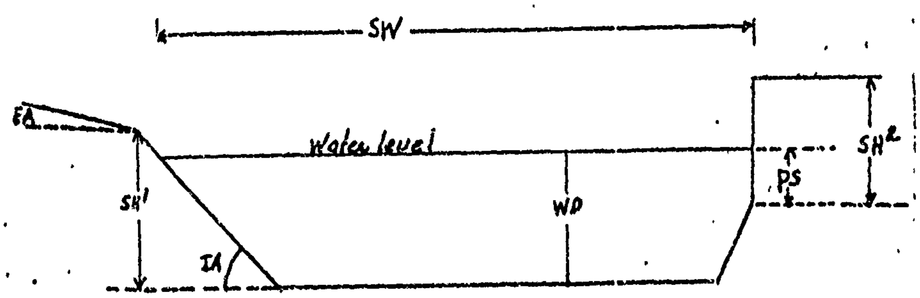
Step Height (SH)		
Map Class	Step Height (SH) in[1]	in[2]
1	<8	<12
2	8-10	12-24
3	>10-12	>24-36
4	>12-14	>36-48
5	>14-16	>48
6	>16-20	
7	>20-30	
8	>30	
x		absent

Position of Step Base (PS)	
Map Class	in
1	>48
2	>36-48
3	>18-36 bwl[3]
4	1-18
5	at water level
6	1-12
7	>12-30 awl[4]
8	>30-48
9	>48
x	absent

Stream Width (SW)	
Map Class	ft
1	0-5
2	>5-10
3	>10-15
4	>15-20
5	>20-25
6	>25-30
7	>30

Stream Depth (SD)	
Map Class	ft
1	<3
2	3-4.5
3	>4.5-15
4	>15

lass ranges used when water depth is <3 ft
lass ranges used when water depth is ≥3 ft
evel
evel



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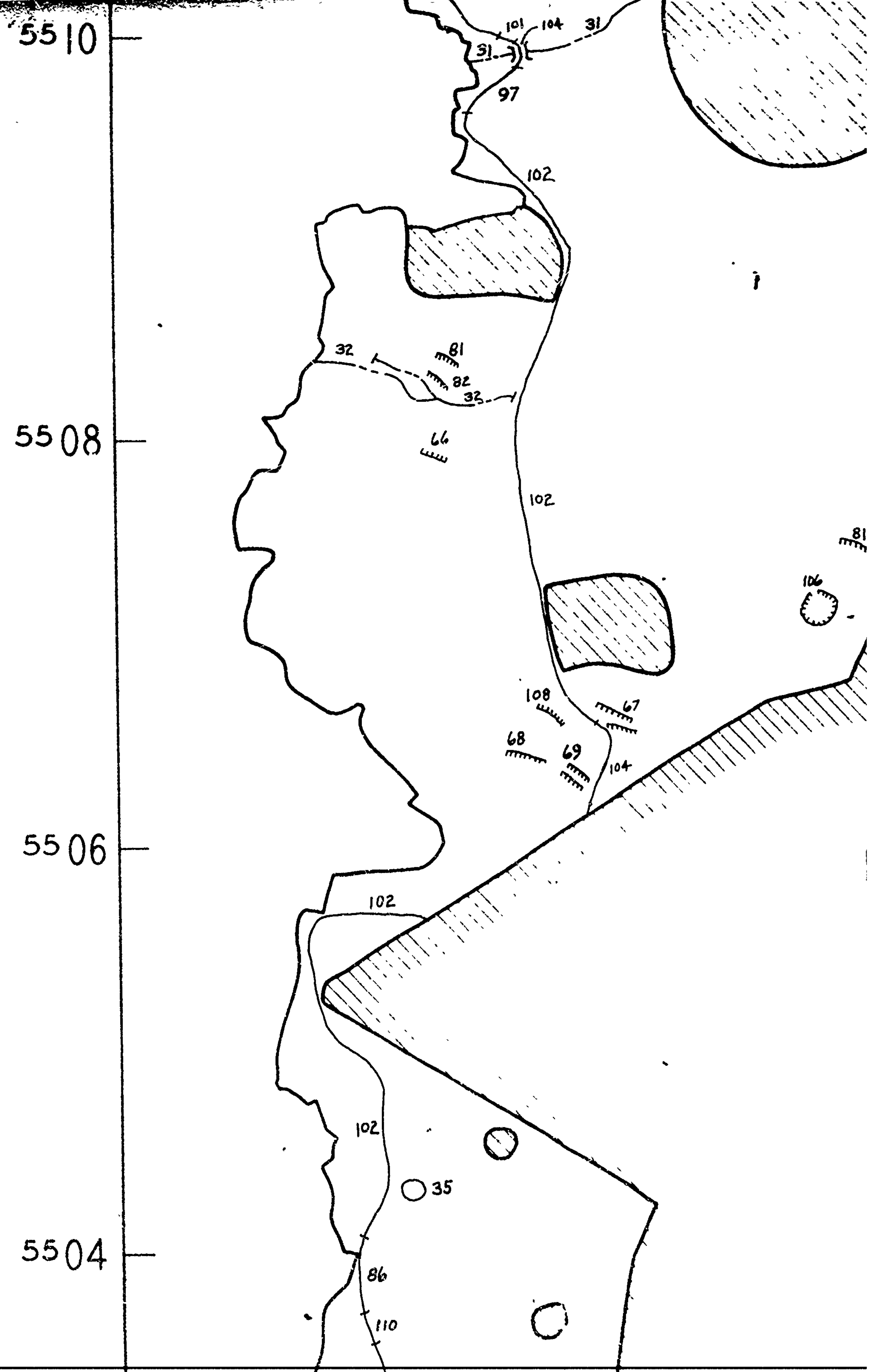

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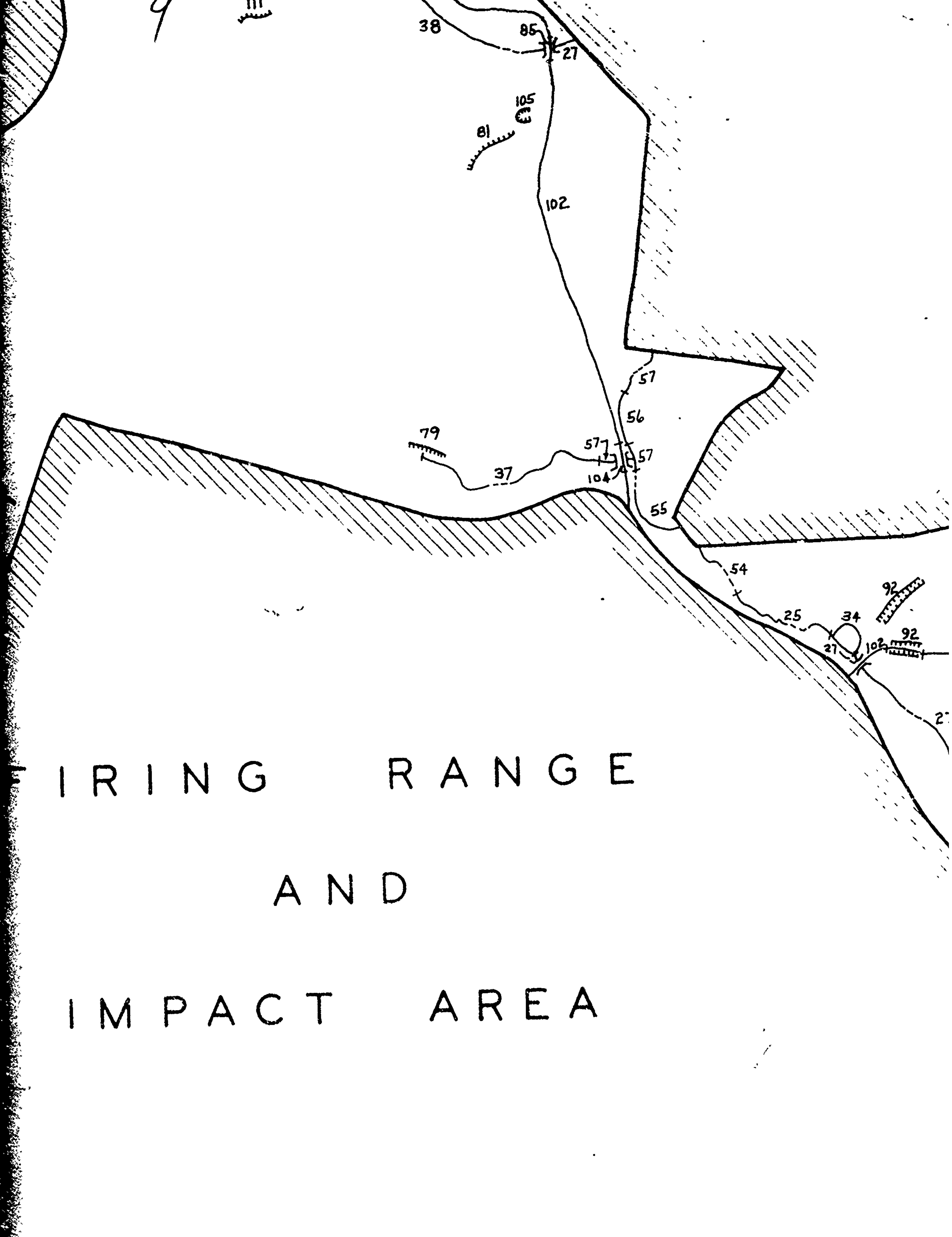

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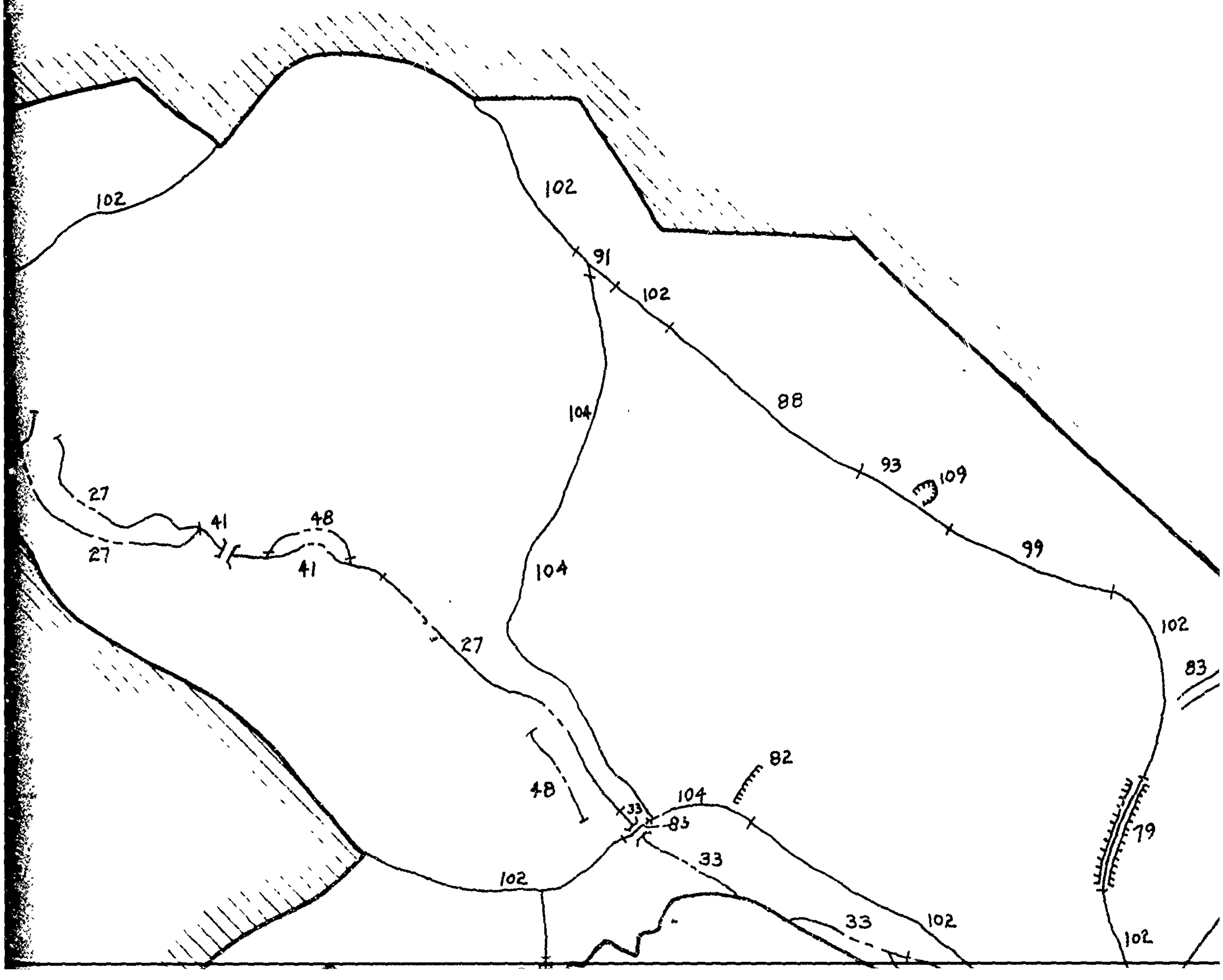

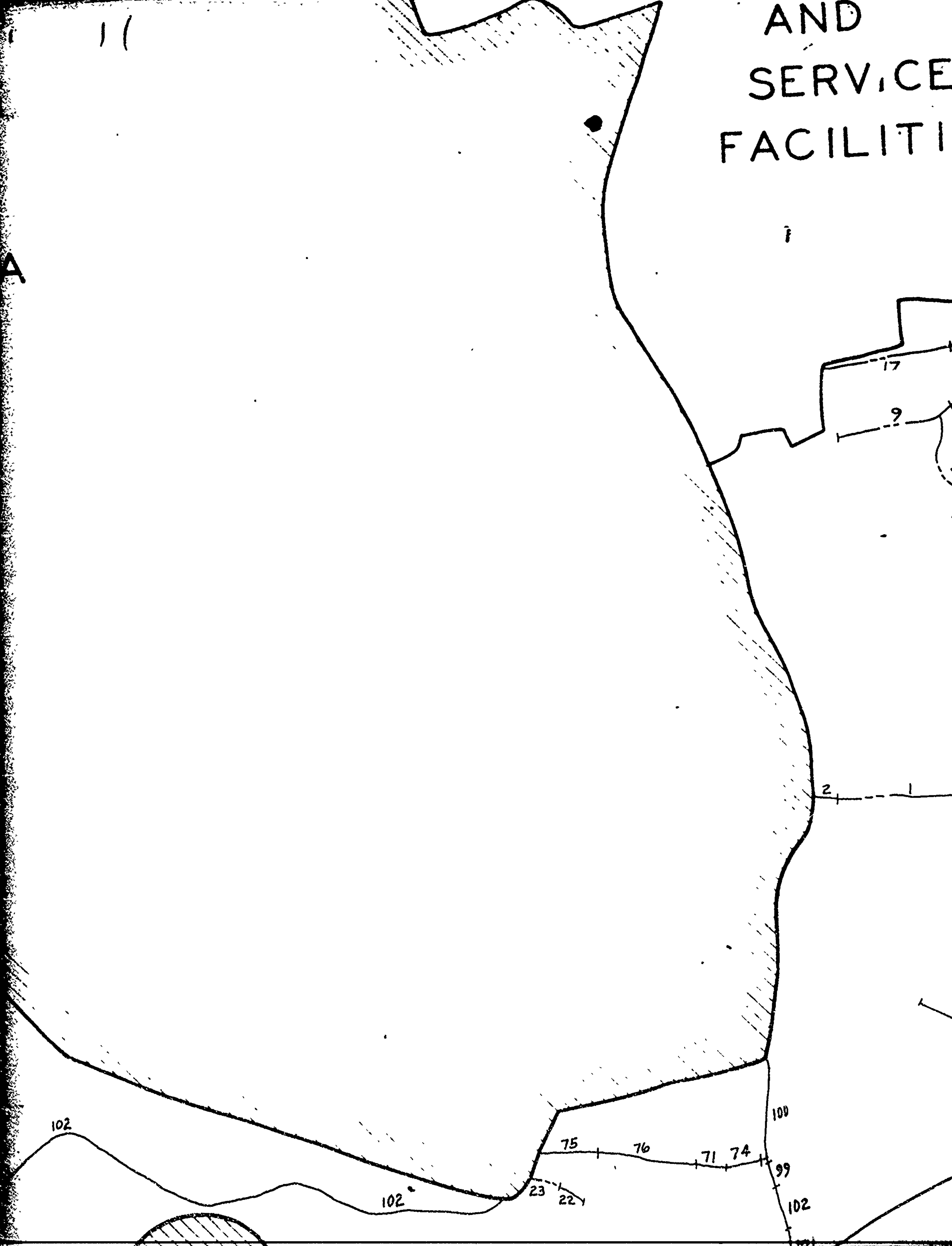
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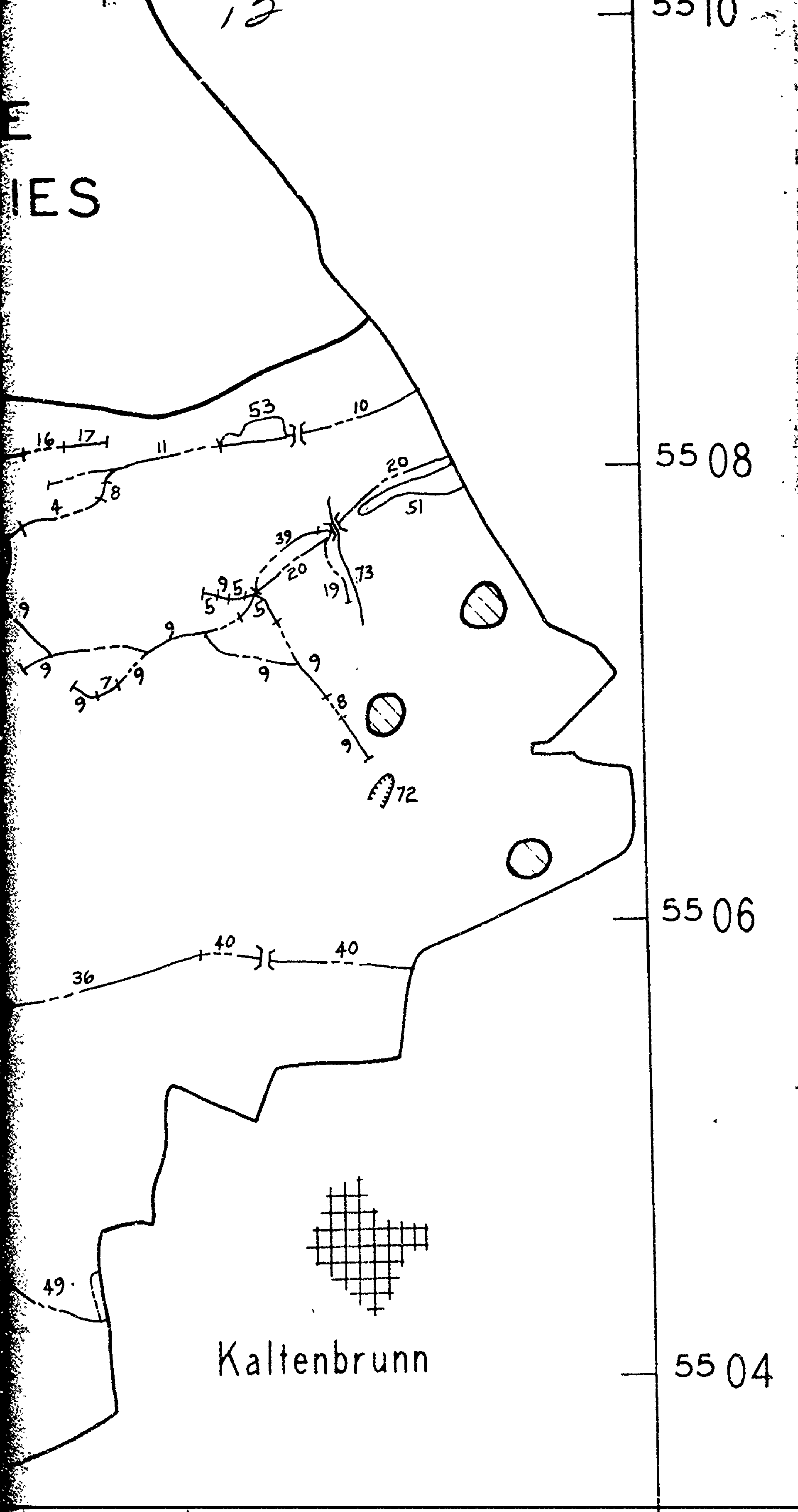

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49	2	10	8		2	10	8	
50	3	3	6	7	5	2	x	x
51	3	3	6	7	5	2	x	x
52	3	3	6	7	5	2	x	x
53	3	3	6	7	5	2	x	x
54	3	10	7		2	6	7	
55	3	10	7		2	6	7	
56	3	10	7		2	6	7	
57	3	10	7		2	6	7	
58	3	10	7		3	10	7	
59	3	10	7		3	10	7	
60	3	10	8		1	6	8	
61	5	10	8		5	10	8	
62	6	2	x	x	1	4	7	

Map Unit	SURFACE GEOMETRY Exterior Angle	Interior Angle	S He
63	1/1	1/10	
64	1/1	10/1	
65	1/2	1/10	
66	1/2	1/10	
67	1/3	1/10	
68	1/3	1/10	
69	1/3	4/7	
70	2/1	10/1	
71	2/2	6/6	
72	2/2	6/6	
73	2/2	9/9	
74	2/2	9/9	
75	2/2	9/9	
76	2/2	9/9	
77	2/2	10/10	
78	2/3	9/9	
79	3/1	8/1	
80	3/1	10/1	
81	3/1	10/1	
82	3/1	10/1	
83	3/2	8/8	
84	3/3	7/7	
85	3/3	7/7	
86	3/3	7/7	
87	3/3	7/7	
88	3/3	7/7	
89	3/3	7/7	
90	3/3	7/7	
91	3/3	7/7	
92	3/3	7/7	
93	3/3	7/7	
94	3/3	7/7	
95	3/3	7/7	
96	3/3	7/7	
97	3/3	7/7	
98	3/3	7/7	
99	3/3	7/7	
100	3/3	7/7	
101	3/3	7/7	
102	3/3	7/7	
103	3/3	7/7	

13

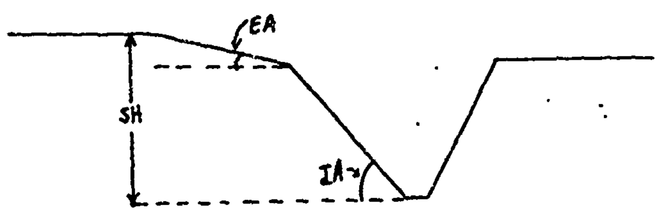
		1	1	7	7	7	7	7	7	7	7	7
		1	1	4M	7	7	7	7	7	7	7	7
		1	1	5	7	7	7	7	7	7	7	7
	x	7	3	6M	7	7	7	7	7	7	7	7
	x	7	3	7	2	2	2	2	4	7	7	7
	x	7	3	7	3	3	3	3	4	4	4	7
	x	7	3	7	7	7	7	7	7	7	7	7
7		3	1	4M	2	2	2	2	2	4	6	7
7		3	1	5	2	2	2	2	2	4	6	7
7		3	1	5	2	2	2	2	4	7	7	7
7		3	1	5	7	7	7	7	7	7	7	7
7		1	1	6	2	2	2	2	3	4	5	7
7		1	1	6	7	7	7	7	7	7	7	7
8		3	1	6M	7	7	7	7	7	7	7	7
8		4	1	4M	7	7	7	7	7	7	7	7
7	7	7	2	4M	7	7	7	7	7	7	7	7

RY		SURFACE COMPOSITION	VEGETATION							
			Spacing of Stems > the Specified Diameter, in.							
	Step Height		1.0	2.5	4.0	5.5	7.0	8.5	10.0	Visibility
	1/8	7	7	7	7	7	7	7	7	7
	8/1	7	7	7	7	7	7	7	7	7
	1/8	7	2	2	2	2	4	7	7	7
	1/8	7	7	7	7	7	7	7	7	7
	1/8	7	7	7	7	7	7	7	7	7
	1/8	7S	7	7	7	7	7	7	7	7
	5/7	7S	7	7	7	7	7	7	7	7
	8/1	7	7	7	7	7	7	7	7	7
	8/8	7	3	3	3	3	3	4	5	7
	8/8	7	7	7	7	7	7	7	7	7
	8/8	7	2	2	2	2	4	7	7	7
	8/8	7	3	3	4	4	4	5	5	4
	8/8	7	7	7	7	7	7	7	7	7
	8/8	7S	2	2	2	2	3	4	4	7
	8/8	7	7	7	7	7	7	7	7	7
	8/8	7	7	7	7	7	7	7	7	7
	8/1	7	7	7	7	7	7	7	7	7
	8/1	7	4	4	4	4	4	5	5	7
	8/1	7	7	7	7	7	7	7	7	7
	8/1	7S	7	7	7	7	7	7	7	7
	7/8	7	2	2	2	2	4	6	7	7
	8/8	1	7	7	7	7	7	7	7	7
	8/8	6M	7	7	7	7	7	7	7	7
	8/8	7	1	1	2	4	7	7	7	7
	8/8	7	1	2	2	5	5	6	7	2
	8/8	7	2	2	2	2	2	2	3	7
	8/8	7	2	2	2	2	2	3	4	7
	8/8	7	2	2	2	2	3	3	4	7
	8/8	7	2	2	2	2	3	4	4	7
	8/8	7	2	2	2	2	3	4	5	7
	8/8	7	2	2	2	2	4	6	7	7
	8/8	7	2	2	2	2	4	7	7	7
	8/8	7	3	3	3	3	3	3	4	7
	8/8	7	3	3	3	3	3	4	4	7
	8/8	7	3	3	3	3	3	4	5	7
	8/8	7	3	3	3	3	4	4	4	7
	8/8	7	3	3	4	4	4	5	5	4
	8/8	7	4	4	4	4	4	5	5	7
	8/8	7	6	6	6	6	6	6	7	7
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	7	7	7

Surface Geometry*

Approach Angle (EA-IA)	
Map Class	deg
1	0-1.5
2	>1.5-4.5
3	>4.5-10
4	>10-17
5	>17-22
6	>22-27
7	>27-31
8	>31-36
9	>36-45
10	>45

Step Height (SH)	
Map Class	in
1	<8
2	8-10
3	>10-12
4	>12-14
5	>14-16
6	>16-20
7	>20-30
8	>30



Surface Composition**

Map Class	6-12 in RCI
1	10
2	>10-20
3	>20-35
4	>35-50
5	>50-75
6	>75-125
7	>125

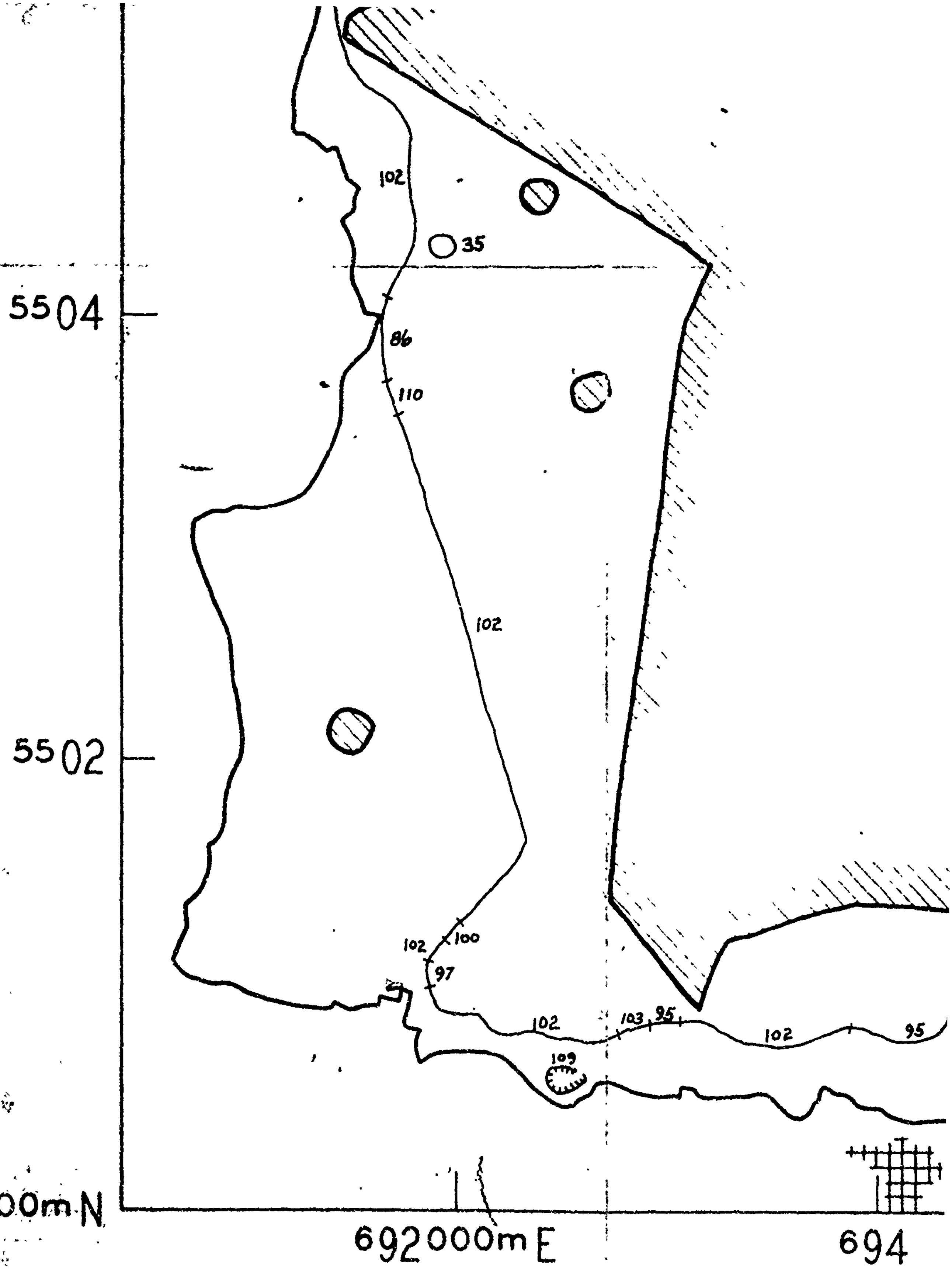
Map Class	0-6 in CI
1S	0-20
2S	>20-40
3S	>40-75
4S	>75-125
5S	>125-175
6S	>175-250
7S	>250

Map Class	6-12 in CI
1M	0-15
2M	>15-30
3M	>30-45
4M	>45-60
5M	>60-80
6M	>80

Vegetation***

Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

Visibility	
Map Class	ft
1	<15
2	>15-21
3	>21-27
4	>27-33
5	>33-39
6	>39-45
7	>45


102
35
5504
86
110
102
5502
102
100
97
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103
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102
95
109
5500000m N
692000m E
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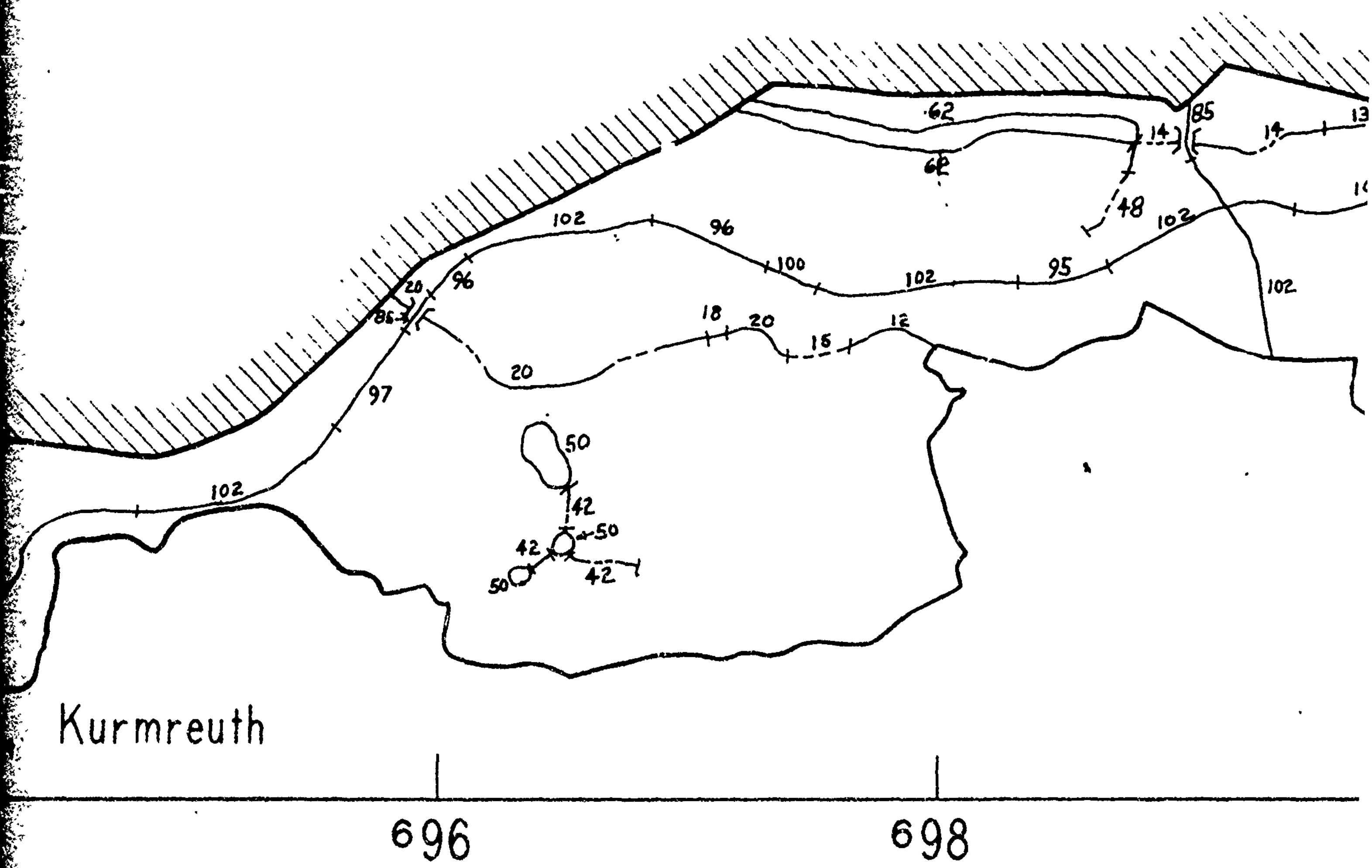
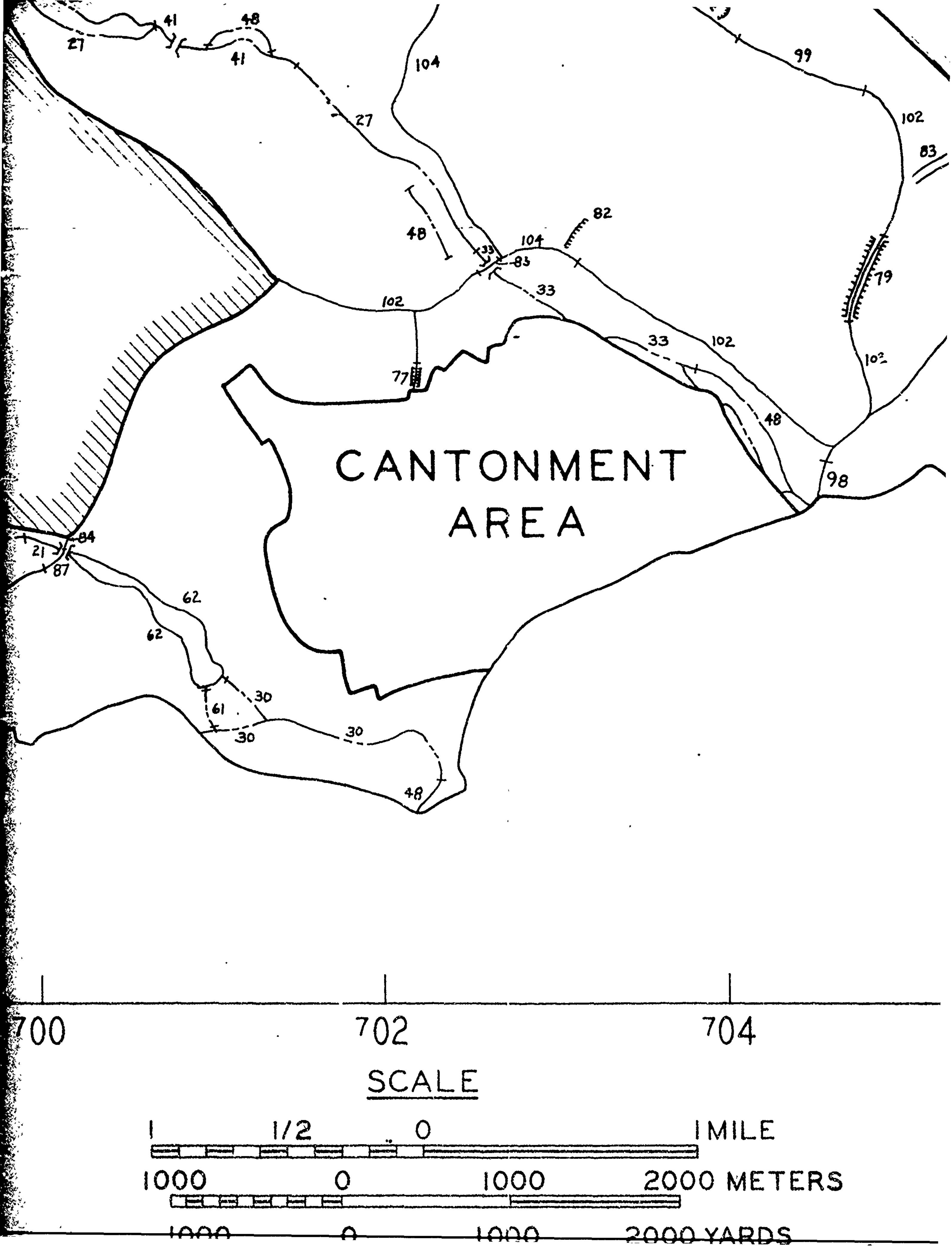
15

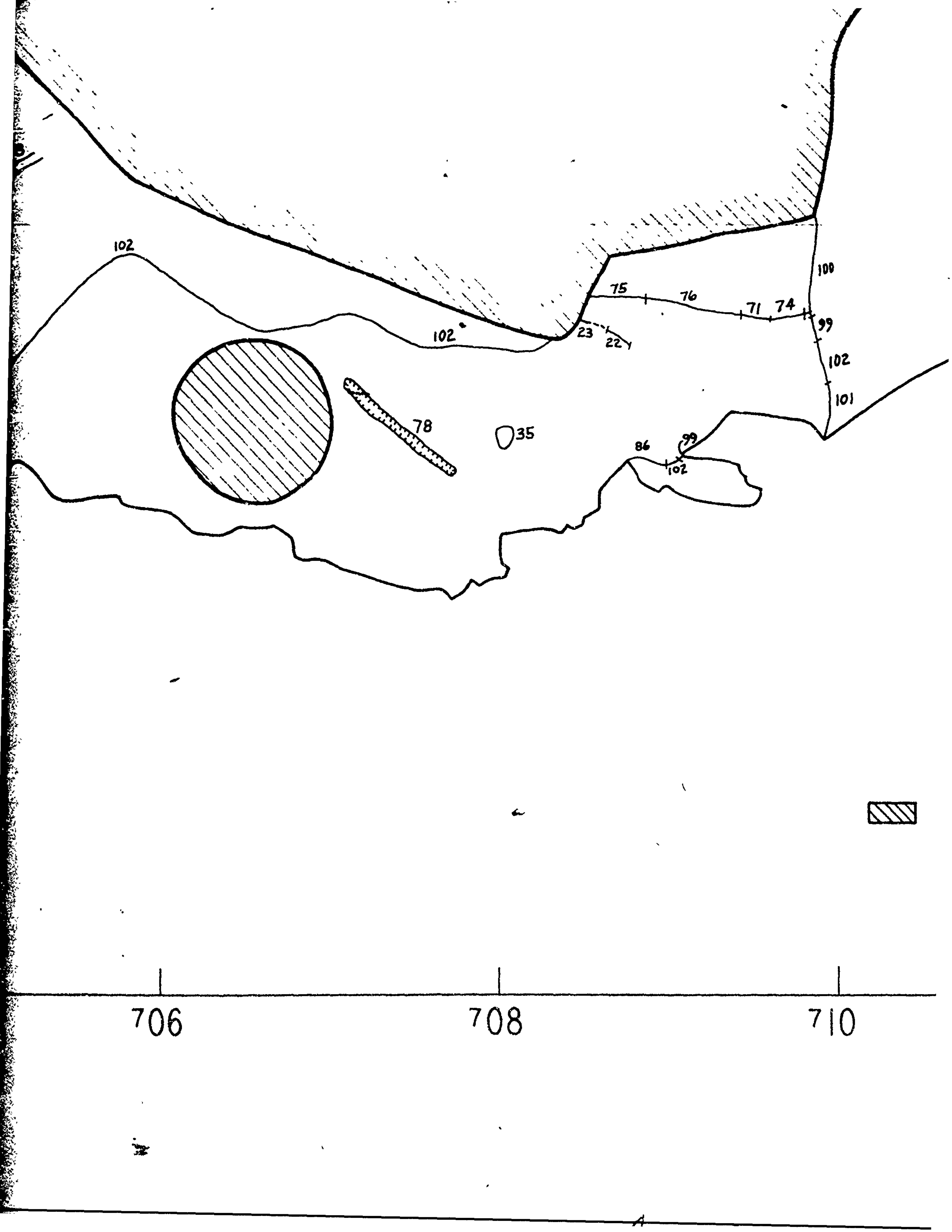
AND

IMPACT AREA





CANTONMENT AREA
27
41
48
41
27
104
99
102
83
82
104
33
83
48
33
102
79
77
33
102
102
48
98
84
21
87
62
62
30
61
30
30
48
700
702
704
SCALE
1
1/2
0
1 MILE
1000
0
1000
2000 METERS
1000
0
1000
2000 YARDS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22
78
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99
102
706
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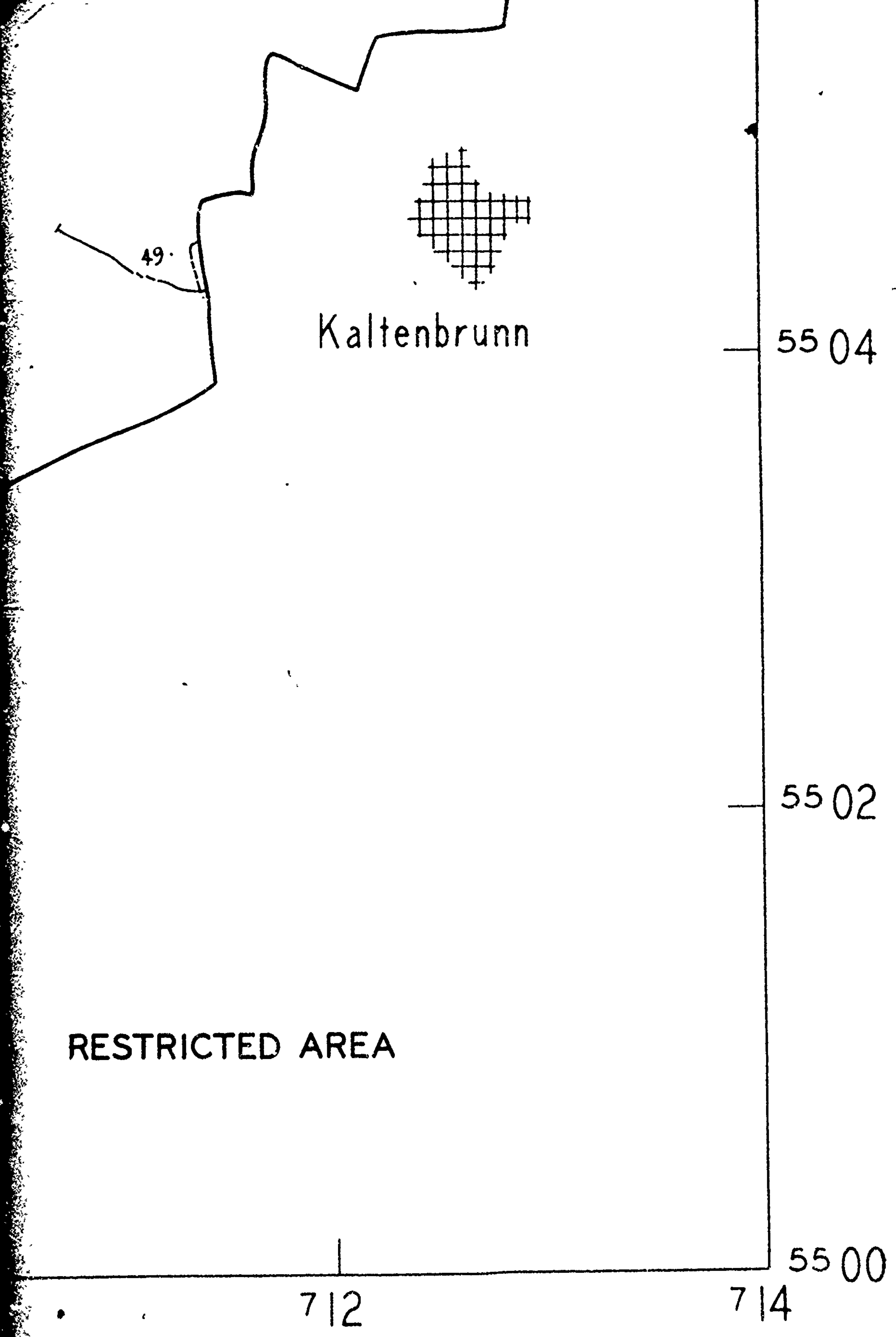
710



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91	3/3	7/
92	3/3	7/
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98	3/3	7/
99	3/3	7/
100	3/3	7/
101	3/3	7/
102	3/3	7/
103	3/3	7/
104	3/3	7/
105	3/3	1
106	3/3	1
107	3/3	1
108	4/1	1
109	4/4	1
110	4/5	7.
111	5/1	1

7/7	8/8	1	7	7	7	7	7	7	7	7
7/7	8/8	6M	7	7	7	7	7	7	7	7
7/7	8/8	7	1	1	2	4	7	7	7	7
7/7	8/8	7	1	2	2	5	5	6	7	2
7/7	8/8	7	2	2	2	2	2	2	3	7
7/7	8/8	7	2	2	2	2	2	3	4	7
7/7	8/8	7	2	2	2	2	3	3	4	7
7/7	8/8	7	2	2	2	2	3	4	4	7
7/7	8/8	7	2	2	2	2	3	4	5	7
7/7	8/8	7	2	2	2	2	4	6	7	7
7/7	8/8	7	2	2	2	2	4	7	7	7
7/7	8/8	7	3	3	3	3	3	3	4	7
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7/7	8/8	7	3	3	3	3	4	4	4	7
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7/7	8/8	7	6	6	6	6	6	6	7	7
7/7	8/8	7	7	7	7	7	7	7	7	7
7/7	8/8	7S	2	2	2	2	3	4	4	7
7/7	8/8	7S	7	7	7	7	7	7	7	7
10/10	8/8	7	2	2	2	2	4	6	7	7
10/10	8/8	7	7	7	7	7	7	7	7	7
10/10	8/8	7S	7	7	7	7	7	7	7	7
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10/10	8/8	7	7	7	7	7	7	7	7	7
7/8	5/4	7	7	7	7	7	7	7	7	7
10/1	8/1	7	7	7	7	7	7	7	7	7

Vegetation ***

Stem Spacing	
Map Class	ft
1	0-8
2	>8-12
3	>12-15
4	>15-20
5	>20-25
6	>25-30
7	>30

Visibility	
Map Class	ft
1	<15
2	>15-21
3	>21-27
4	>27-33
5	>33-39
6	>39-45
7	>45

TERRAIN FACTOR COMPLEX MAP
WEST GERMANY

LINEAR FACTOR COMPLEXES
GRAFENWOHR

PLATE 6

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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Vicksburg, Miss.

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2b. GROUP

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

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John H. Shamburger

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

U. S. Army Ballistic Research Laboratory
Aberdeen Proving Ground, Md.

13. ABSTRACT

This study was performed to classify and map terrain for ground mobility purposes in accessible areas of three German military reservations (Baumholder, Bergen-Hohne, and Grafenwohr). The terrain was classified in terms of surface geometry, surface composition, vegetation, and hydrologic geometry factors that affect vehicle mobility. Mapping of the terrain factors was accomplished through interpretation of air photos. To provide the necessary ground control data for photo-interpretation processes, a field data collection program was conducted, and data were collected according to established procedures. The field data were tabulated and placed in established class ranges significant to ground mobility. Utilizing the field data, an air photo-interpretation method was applied to estimate the established terrain factor-value classes from the geometric, tonal, and textural characteristics of the air photo patterns. Terrain characteristics were extrapolated from the sample to the unsampled areas, and factor-family maps at a scale of 1:25,000 were prepared of the three study areas. The factor-family maps were then compiled into areal and linear factor-complex maps. The areal factor-complex maps display the areal extent of discrete combinations of factor-value classes of surface geometry, surface composition, and vegetation factor families. The linear factor-complex maps display the factor values of linear features (i.e. streams, canals, road embankments, etc.) and the surface composition and vegetation associated with them.

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Mapping						
Mobility						
Photo interpretation						
Terrain						
West Germany						